POWER

Vol. 38 NEW YORK, NOVEMBER 11, 1913 No. 20

AVOIDING THE ROCKS

Latest Addition to Fisk Street Station

SYNOPSIS—The present addition, consisting of one 25,000-kw. and one 20,000-kw. turbines, marks a departure in the company's practice from vertical to horizontal units and brings the total service capacity of the station up to 165,000 kw. A kinetic air ejector for the condenser of the larger turbine is a feature expected to produce an exceptionally high vacuum. The steam-producing equipment is arranged on the unit plan and coal- and ash-handling facilities are unusually complete.

In our issue of Nov. 4 the 25,000-kw. English Parsons turbine for the Commonwealth Edison Co., of Chicago, was described. This unit is now being installed in the new extension to Fisk St. station. The extension is also to contain a 20,000-kw. horizontal turbo-generator to be supplied by the General Electric Co. The installation of horizontal units is a departure from the usual practice of the company, at least in this particular station. Since its inauguration in 1903 nothing in generating units has been installed but vertical Curtis turbo-generators. At the present writing the existing station has reached a service rating of 120,000 kw., and the addition of 45,000 kw. will give to Fisk St. a total capacity of 165,000 kw. The extension for the new equipment is now under construction and extends back for a distance of 170 ft. to the south branch of the Chicago River. It is about 25 ft. wider than the older portion of the building, which measures 240 ft. The total length of the building, including the extension, will be 675 ft.

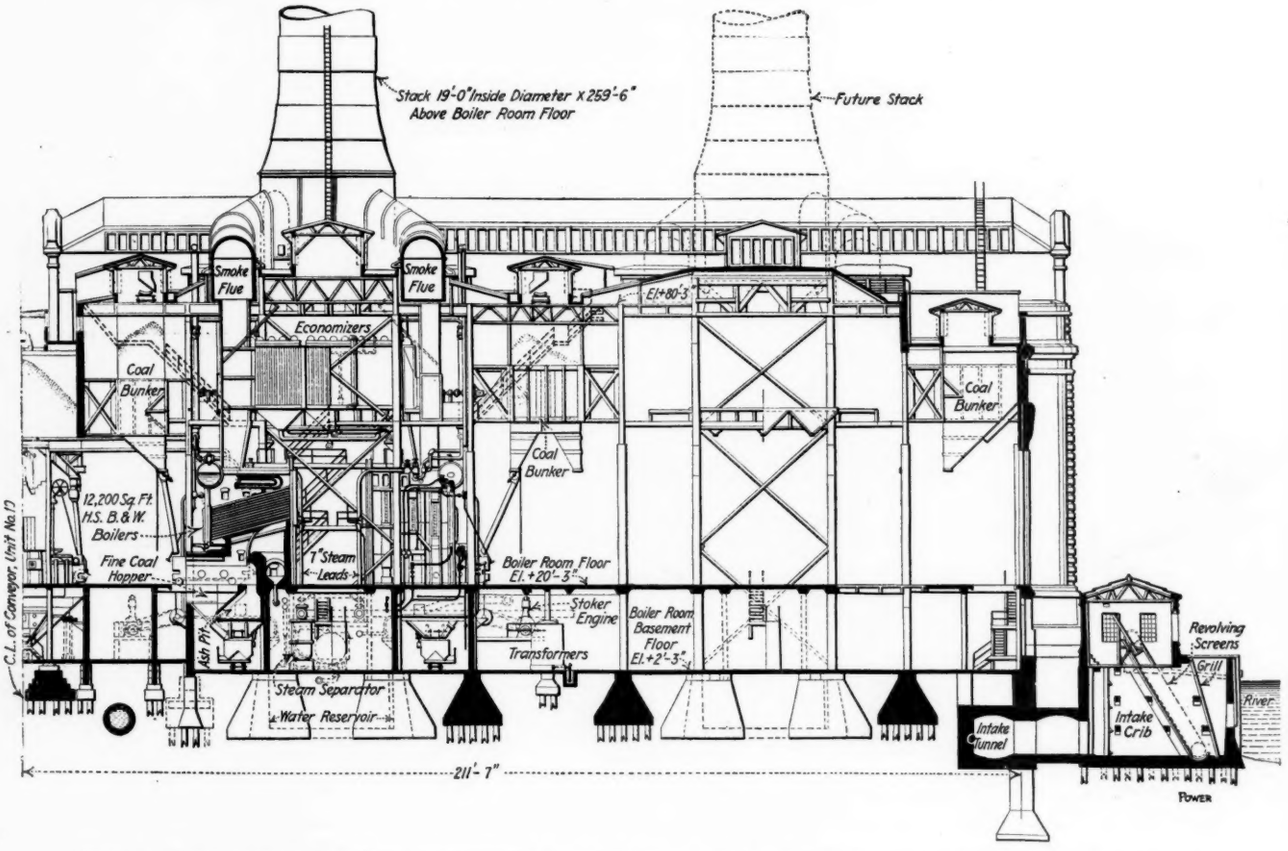


FIG. 1. TRANSVERSE SECTION THROUGH BOILER ROOM OF NEW EXTENSION TO FISK STREET STATION

BOILERS AND ACCESSORIES

As in the past, the unit system has been adopted. Individual groups of boilers supply the particular unit for which they are installed. An extension for this and other units is being added to the switch-house. All units and their accessories are so arranged that they can be operated practically independently. The general arrangement of the present addition to the plant is shown in the accompanying illustrations.

For the 25,000-kw. Parsons turbine the boiler equipment consists of four cross-drum type B. & W. water-tube boilers, which are of especially wide section, 42 tubes in width, with headers 14 tubes high. Each boiler contains 12,200 sq.ft. of heating surface and about 20 per cent. additional surface for superheating. They are equipped with chain-grate stokers and steel-encased settings. Each boiler is provided with two stokers separated by a firebrick wall which comes slightly above the surface of the grates. These stokers are 10 ft. 6 in. wide and 13 ft. long. The boilers are designed to evaporate 80,000 lb. of water per hour under continuous working conditions. The maximum working pressure is 225 lb. per sq.in., and the normal pressure 210 lb. gage. The superheaters will give 225 deg. F. superheat when operating at or near the maximum capacity.

As shown in the drawings, economizers have been provided, one for each boiler, containing 8500 sq.ft. of heating surface made up of 528 twelve-foot tubes, arranged in three groups of 16 sections each. The first group is

12 tubes wide; the second 11 tubes wide, and the third 10 tubes wide. As regards water circulation, the three groups are connected in series, and the circulation in each group is up the first eight sections, down the next four, and up the last four. Each economizer is equipped with an induced-draft fan having a capacity of 80,000 cu.ft. per min. and designed to maintain 1½-in. draft in the uptake of the boiler. Under ordinary operating conditions the economizers are designed to raise the temperature of the feed water about 150 deg. This equipment was furnished by the B. F. Sturtevant Co.

One smoke-stack has been provided for two units. In this particular case it will serve eight boilers. The stack is 19 ft. inside diameter and its height 250 ft. above the boiler-room floor.

Coal- and Ash-Handling Equipment

This feature of the plant is of particular interest, as every facility is provided to handle quickly and with the greatest economy the large quantity of coal required by the boilers. Coal cars are brought into the train shed on either unloading track, from which point the coal may be dumped directly into the hopper of the primary crusher, if the cars are of the drop-bottom variety; or if gondola cars, the coal may be unloaded by grab-bucket cranes and dropped over the side into the crusher hopper. The primary crusher is intended to reduce all lumps to about 3- or 4-in. cubes, and from it the coal is passed into the lower horizontal run of either of two Mead-Morrison overlapping bucket conveyors, which will care for the four groups of boilers. The bucket conveyors elevate the coal to a point above the boiler-room coal bunkers, and deliver it to the secondary crushers to be reduced to ¾ in. size. All of the crushers were furnished by Orton & Steinbrenner. From this point the coal is taken by a Robins belt conveyor running at right angles to the bucket conveyors, and is delivered to the bunkers over the boilers. There are three belt conveyors for the four groups of boilers. The bucket conveyors have a capacity of 175 tons of coal per hour each, at a speed of 45 ft. per min. The belt conveyors have a like capacity, at a speed of 250 ft. per min.

Per boiler, the capacity of the coal bunkers is 225 tons. In addition for serving four station units, there are four storage bunkers overhead in the train shed, with an aggregate capacity of 3360 tons, and receiving hoppers having a capacity of 1320 tons.

The removal of ashes will be accomplished by means of small electrically driven ash cars operating in the boiler-room basement. These cars discharge into a receiving hopper, which delivers to the bucket conveyor previously mentioned, and which may be used to elevate the ashes to a storage bunker above the track in the train shed, having a capacity of 1180 tons. From this point the ashes are discharged into standard railway cars for removal.

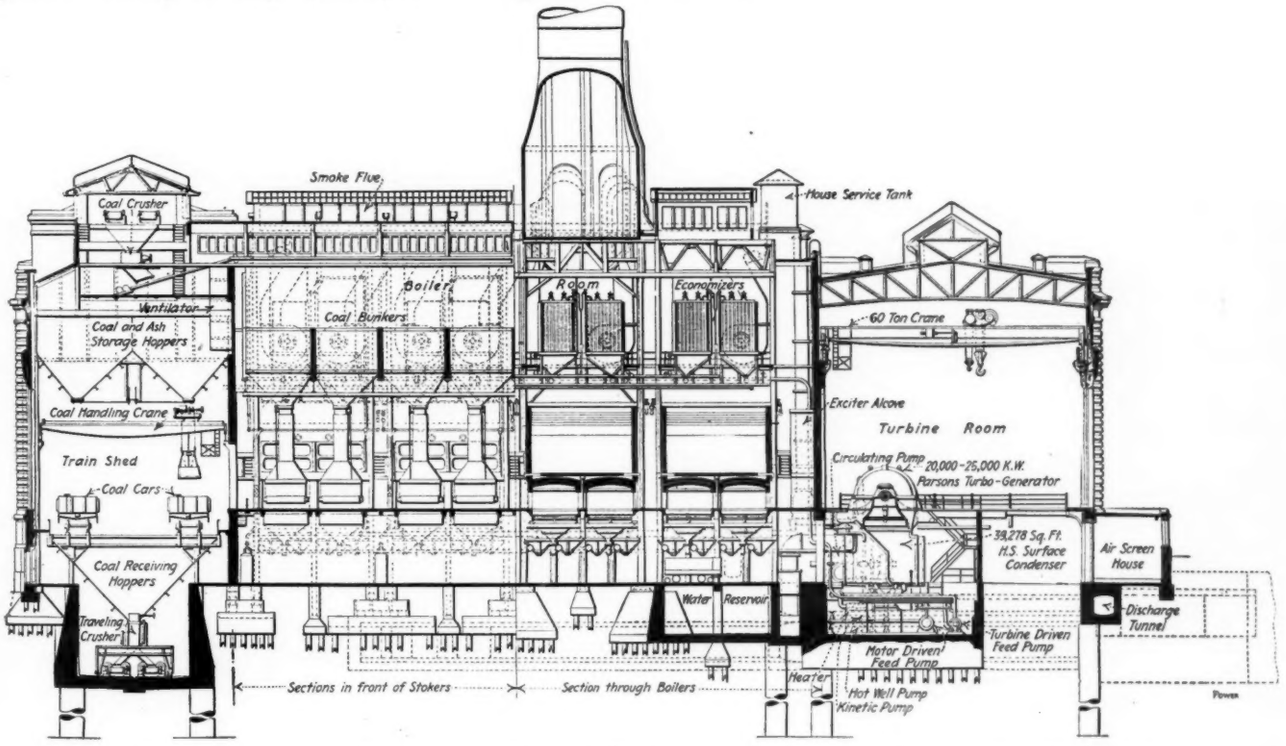


Fig. 2. Section through Boiler and Turbine Rooms of the New Addition to Fisk Street Station

20,000-Kw. Unit

The General Electric horizontal turbo-alternator to be installed has a continuous full-load rating of 20,000 kw. at 80 per cent. power factor, or 25,000 kv.-a. Current will be generated at 12,000 volts, 60 cycles, and the unit will operate at a speed of 1200 r.p.m. The turbine is of the Curtis single-flow type, the first wheel having a double row of buckets, and the remaining wheels each having a single row of buckets. The shaft bearings are provided with forced lubrication from a pump geared to the main shaft. The bearings are water-jacketed, in addition to which the oil will be cooled, as it circulates, by means of coils immersed in the turbine-oil reservoir. The main turbine housing is anchored at the exhaust end to the sub-base and is supported on a sliding bearing at the throttle end, this arrangement being adopted to prevent expansion strains. The generator housing is bolted rigidly to

the sub-base. Governing is accomplished by means of the system heretofore used on Curtis turbines. The generator is arranged for self-ventilation by means of vanes on the rotating field. Excitation is provided by means of a direct-connected exciter operating at 250 volts.

The entire condenser installation for this unit is being furnished by Henry R. Worthington. The condenser is located directly beneath the turbine-exhaust outlet and supported partly by the turbine housing and partly on beams. It contains 35,000 sq.ft. of cooling surface, of 1-in. O. D. No. 18 B.w.g. tubing, the tubes being about 15 ft. long. The condenser shell is of semi-circular cross-section, built of cast iron and heavily ribbed. The condenser is arranged for two passes of the circulating water. The steam inlet is 8 ft. by 14 ft. 6 in., and the connection for circulating water 42 in. in diameter.

The circulating outfit consists of a motor mounted on a base plate between two independent centrifugal pumps, each having its own suction and discharge connections. The discharge pipes are interconnected at the inlet to the condenser, and are provided with valves which permit cutting out either pump. In addition, the pumps are provided with shaft couplings, so that either may be disconnected from the motor. The combined capacity of the two circulating pumps is 36,000 gal. per min., at 375 r.p.m., against a total dynamic pressure of 15 ft. One pump alone will deliver 26,500 gal. at the reduced head consequent upon the lessened velocity of the water through the condenser and connections. With this arrangement the capacity of both pumps will ordinarily be used during the warmer months, and in winter one pump alone will deliver sufficient water.

The arrangement of the hotwell pump is similar to that of the circulating-pump unit just described. The dry-vacuum pump is of the reciprocating angle type, as manufactured by the Laidlaw-Dunn-Gordon Co., with vertical steam cylinder, and horizontal vacuum cylinder. Both steam and vacuum cylinders are double-acting, the steam cylinder being 10 in. in diameter and the vacuum cylinder 35 in., with a common stroke of 30 in. At the maximum speed of the vacuum pump of 100 r.p.m., the displacement is 3340 cu.ft. per min.

The installation of boilers and economizers is similar in all respects to that of the 25,000-kw. Parsons unit. For boiler feed two independent pumps are provided. These pumps are to be of the turbine-driven horizontal type, having three stages, and will discharge 375 gal. per min. when operating at approximately 3000 r.p.m. The exhaust from the steam auxiliaries is all carried to a Baragwanath horizontal open-type exhaust feed-water heater, which is constructed of ½-in. steel plate with the usual arrangement of trays. It will have a capacity of 300,000 lb. per hour and is guaranteed to heat the water from 65 to 130 deg. F.

For the removal of the air and noncondensable vapors from the condenser of the 25,000-kw. unit, a kinetic ejector has been provided. This piece of apparatus takes the place of the so called dry-vacuum pump. It will be fully described on other pages of this issue.

This installation was designed by Messrs. Sargent & Lundy, Chicago, consulting engineers for the Commonwealth Edison Co., and with them were associated Messrs. Merz & McLellan, of Newcastle-on-Tyne and London, in connection with the design and construction of the Parsons turbine unit and auxiliaries.

Cost of the Smoke Nuisance to Pittsburgh*

Before considering the loss to Pittsburgh, due to the smoke evil, it is interesting to note the estimated cost of the evil to other cities.

In 1899 the annual cost to London was estimated at $26,000,000. The committee on smoke prevention of the Cleveland Chamber of Commerce in 1909 fixed the loss to Cleveland at $6,000,000, or $12 per capita. Paul Bird declared that the annual loss to Chicago amounted to $17,600,000, or $8 per capita. The loss to Cincinnati has been placed at $8,000,000; this is allowing for a loss of $100 per family of five persons each, the 400,000 population being so divided that there were 80,000 families.

The total extra cost of dry cleaning in the city of Pittsburgh because of the atmospheric conditions is about $750,000.

According to the 1910 Census Report there are 86,942 dwellings in Pittsburgh. No doubt 50,000 of these houses are painted every three years. If it is said that the average cost of painting a house is $40 it then costs Pittsburghers $330,000 more a year for exterior painting than it does the people of other cities.

There are very few of the 104,000 buildings in Pittsburgh which do not have sheet metal either as a cover for the roof, or for gutters, spouts and flashings. If the average cost of renewing sheet-metal work on a building was placed at $100 and it was assumed that the work will last five years in Pittsburgh as against ten years elsewhere, then on 90,000 buildings it would cost Pittsburgh about $900,000 more a year under present conditions than if the city were practically free from smoke. Figuring an average cost of repainting sheet-metal work at $8 and assuming that repainting is necessary in Pittsburgh every three years as against five years elsewhere, it would be found that it would cost Pittsburgh about $108,000 a year more for repainting than it would cost other cities.

Wall papering is found necessary in Pittsburgh every two years, while in other cities it is found necessary only every six or ten years.

Pittsburgh pays $150,000 a year to keep the wall paper in its homes in even presentable condition, and it pays $400,000 more a year for wall papering than do cleaner cities.

On an average it costs Pittsburghers $12 to $14 a year to keep their curtains clean, while it costs the people of other cities $6 to $7.

The smoke in the atmosphere of Pittsburgh necessitates extra artificial lighting in the stores. The same is true of the homes of Pittsburgh. There are about 14,000 homes in the city which use electricity for artificial lighting purposes. The average cost to each home is about $24. If it is allowed that one-fourth of this amount is an expense due to atmospheric conditions which in turn can be traced to smoke, then it costs the 14,000 homes $84,000 a year for the extra lighting required.

The business section of Pittsburgh ranks second in the amount of soot-fall among the twelve stations in various

*Excerpts from a pamphlet by John J. O'Conner and published by the Mellen Institute of Industrial Research and School of Specific Industries.

parts of the city, so the soot-fall is greatest where it does the most damage.

The wholesale and retail stores of Pittsburgh, exclusive of the department stores and larger wholesale dry-goods stores, suffer an annual loss of $1,650,000.

The damage to merchandise in the department stores varies from $6000 to $25,000 for each store; the cost of cleaning from $10,000 to $24,728; and the cost of artifical lighting from $10,000 to $15,000. If the items for the department stores are figured on the same basis as for the wholesale and retail stores, it will be found that the extra cost to them for all items would be in the neighborhood of $175,000.

It costs about $200,000 a year to keep the larger office buildings of Pittsburgh clean. One building pays $320 more a month to clean windows than if that building were located in New York, Boston or Philadelphia.

The artificial lighting bills of the downtown office buildings run from $3000 to $20,000 each annually. The cost of the artificial lighting of all the larger office buildings is in the neighborhood of $125,000. Of this amount no less than $40,000 represents the cost of the artificial lighting necessitated by atmospheric conditions for which the smoke is responsible.

On the fifteen prominent hotels in the city of Pittsburgh it is safe to say that smoke imposes an extra expense of about $22,000 a year.

The extra cost of lighting, cleaning and replacing goods worn by frequent washing to the hospitals is on an average $3600 each, or $55,000 for all the larger ones.

❋ ❋

Best Vacuum with a Cooling Tower

By Paul A. Bancel*

Engineers generally realize that they cannot obtain as high a vacuum with a cooling tower as with a natural supply of cold circulating water. But there is some confusion as to just how high a vacuum is profitable.

The purpose of this analysis is to determine at what vacuum a condensing equipment with the natural-draft type of tower, is the most efficient commercially. The basis of the calculation is 10,000 lb. of steam per hour, which corresponds approximately to a steam consumption of a 500-kw. high-pressure turbine, or a 250-kw. low-pressure turbine. Ten million of British thermal units must be absorbed by the circulating water and dissipated to the atmosphere by the cooling tower.

Fig. 1 gives the sizes of Wheeler-Balcke natural-draft cooling towers required to dissipate the heat at different vacuums and with different quantities of circulating water, with the atmosphere at 75 deg. F. and 70 per cent. humidity. The abscissas represent degrees cooling of water in the tower, as well as gallons per minute.

Attention is drawn to some of the inherent characteristics of natural-draft cooling towers as illustrated by the curves.

(a) For any vacuum, the size of a natural-draft cooling tower dissipating a constant amount of heat may be slightly decreased by increasing the quantity of circulating water pumped over it. This, however, increases the operating cost as well as the first cost of the pump and condenser.

(b) For any given quantity of circulating water, the vacuum may be increased by increasing the size of the tower, but only to a certain limit, beyond which the vacuum cannot be increased, even if the tower is made extremely large.

(c) A natural-draft cooling tower is a chimney, consequently, the higher the temperature of the water the better the draft, the greater the volume of air and the greater the heat dissipation per unit of area.

Attempts have been made to analyze cooling-tower performance by coefficients of heat transmitted per unit of cooling surface, but with unsatisfactory results because the efficiency of a unit of cooling surface depends upon its arrangement as influencing the resistance to the flow of air. With a given design of tower, the cooling is almost entirely dependent upon the amount of air going through it. Like a boiler chimney, the area of its base determines the flow per unit of draft pressure.

In Fig. 1 the amount of heat is constant, but the temperature at which the heat must be dissipated and the amount of water both vary. At the lower temperatures there must obviously be a greater volume of air. But the lower temperature means less draft pressure; hence it is doubly important that there be a greater area of flow. This fact serves to explain the shape and position of the curves.

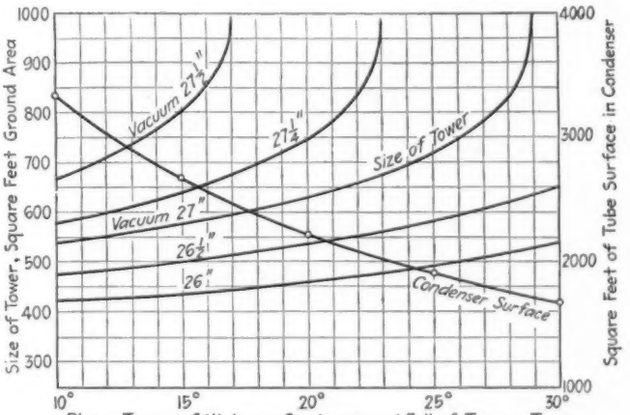


Fig. 1. Relation of Vacuum and Temperature Rise to Size of Tower

The chart also gives a curve of condenser surface corresponding to various quantities in gallons per minute and ranges of water temperature based on a difference of 5 deg. between outlet-water temperature and steam temperature. The curve is based on a heat transmission of 300 B.t.u. and serves for any vacuum, provided the outlet-temperature difference is 5 deg. F.

Let us turn to some actual figures. Suppose the steam consumption of a 500-kw. turbine is 20 lb. per kw.-hr. at 26 in. vacuum, and that the gain resulting from an in-

*Wheeler Condenser & Engineering Co., Carteret, N. J.

crease of each inch in vacuum is 5 per cent., that is, the steam consumption at 26 in. is 20 lb., at 27 in. 19 lb., and 28 in. 18 lb.

Let the yearly load factor be 50 per cent., so that the yearly turbine load is equivalent to 4380 hr. at full load. Assume that coal costs $3 per net ton and that 8 lb. of steam is evaporated per pound of coal; then a pound of steam per hour for a year is worth

$$4380 \times \tfrac{1}{8} \times \frac{3}{2000} \text{ or } \$0.82$$

If the turbine operates at 27 in. vacuum with a steam consumption of 19 lb. per kw.-hr., there will be a saving of 500 × $0.82 or $410. Similarly, at 27½ in. vacuum and 18½ lb. of steam per kw.-hr. the saving is 750 × $0.82 or $615 per year. The question now is, what is the most economical vacuum at which to operate.

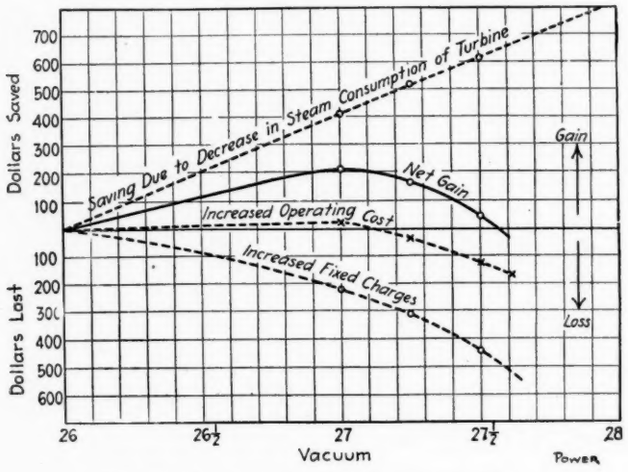


FIG. 2. RELATION OF VACUUM TO GAIN

From Fig. 1, we may read the size of condenser, pump, tower, round area, etc., required for various conditions. For simplicity we will assume a total steam consumption of 10,000 lb. per hr. for all vacuums.

Table 1 shows the size, capacity and cost of the apparatus for four different degrees of vacuum.

TABLE 1

	Vacuum in Inches			
	26	27	27¼	27½
Temperature rise, deg. F.	30	25	20	15
Condenser surface, sq.ft.	1635	1700	2230	2700
Circulating pump, gal. per min.	670	800	1000	1330
Turbine for circulating pump, hp.	20	25	30	35
Ground area of cooling tower, sq.ft.	540	720	740	800
Total cost of condenser, pumps and tower	5625	6740	7350	8200

SAVING ON TURBINE VS. FIXED AND OPERATING COSTS OF CONDENSING EQUIPMENT

Now the fixed charges on the foregoing investments, plus the operating costs, must be balanced against the saving in steam consumption of the turbine.

The fixed charges can be taken at 15 per cent., covering interest, taxes, depreciation, etc.

Table 2 summarizes the cost of the complete tower and condenser outfit, at different vacuums, also the fixed charges at 15 per cent. and the increase of fixed charges over the 26-in. equipment.

TABLE 2

Vacuum, In.	Cost of Condensing and Tower Equipment	Annual Fixed Charges at 15 Per Cent.	Increase over Cost for 26 In.
26	$5265	$790	
27	6740	1010	$220
27¼	7350	1100	310
27½	8200	1230	440

Considering next the operating charges of the condensing equipment, we find it necessary to make a correction for the saving due to feed-water heating by exhaust steam. While a large share of the heat is returned to the feed water, a certain percentage is consumed in work and friction; also, some of the heat is lost by radiation and leakage, and at times there may be insufficient feed water to condense all the steam in the feed-water heater. A fair assumption is that 75 per cent. of the heat is returned to the feed water, or that the steam consumption chargeable to the condensing apparatus is 25 per cent. of the gross.

The gross and net steam consumption of the condenser auxiliaries for the different vacuums above stated may be set down as follows:

TABLE 3

Vacuum, In.	Steam Consumption Air Pump, Lbs.	Circulating Pump per Hour	Chargeable to Condensing Plant, 25 Per Cent. Lb. per Hr.	Value of Steam Consumption per Year
26	600*	1200	450	$369
27	175	1500	420	345
27¼	175	1800	500	410
27½	280	2100	600	492

*This comparatively high figure is explained by the fact that for the 26-in. vacuum a direct-acting reciprocating pump could be used, while at the higher vacuums a more efficient pump would be used.

The value of the steam consumed per year, as given in the last column, is based on 50 per cent. load factor, $3 per ton for coal, and the use of 8 lb. of steam per pound of coal.

With the foregoing data available we are now ready to determine at what vacuum the greatest net saving is obtained.

Table 4 is based on Tables 2 and 3 and gives the saving and losses in dollars at different vacuums as compared to 26-in. conditions.

In the last column the net saving is tabulated.

TABLE 4

Vacuum, In.	Saving by Decreased Steam Consumption of Main Turbine	Additional Fixed Charges	Additional Operating Cost	Net Yearly Saving over 26-In. Outfit
27	$410	$220	$24	$214
27¼	513	310	41	162
27½	615	440	123	52

The above table shows that the most economical point lies near 27 in. This is shown graphically by the chart, Fig. 2, in which the heavy curve represents the net saving, the highest point indicating the vacuum required for the highest commercial efficiency. This curve also shows that if sufficient money were expended to obtain a vacuum as high as 27.6 in. there would be neither gain nor loss as compared with 26-in. operation.

The conclusions are all based on 50 per cent. load factor, $3 per ton for coal, 8 lb. steam per lb. of coal, a turbine saving 5 per cent. of its steam per inch increase in vacuum over 26 in., and having a steam consumption of 20 lb. at 26-in. vacuum, a Wheeler-Balcke tower and atmospheric conditions of 75 deg. F. and 70 per cent. humidity.

These conditions vary. The particular load factor at which the purchaser will operate his plant, the size of the plant, the type of turbine or engine, the cost of coal, the interest which he is obliged to pay on money, all affect the problem.

The chart, Fig. 1, can be used as a basis in most cases, multiplying by the ratio of actual steam to 10,000 lb., and the method outlined for obtaining chart No. 2, followed through for the exact conditions at hand.

Designing a 100-Hp. Horizontal Tubular Boiler

By T. G. Ranton

SYNOPSIS—Instruction is herein given how to determine the proper size of boiler to develop 100 hp., taking into account the grate area, heating surface and number of tubes, also the thickness of the shell plate and tube heads, number and size of braces, etc.

It is well known that the term horsepower belongs to the engine and not to the boiler. A boiler should be estimated from its evaporative capacity, that is to say; with so much coal per hour a boiler will evaporate so much water per hour at a given temperature into steam at a given pressure.

The standard horsepower is the evaporation of 30 lb. of water per hour into steam at 70 lb. pressure with a feed-water temperature at 100 deg. F. Therefore, a boiler necessary to develop 100 hp. must evaporate 3000 lb. of water per hour. One pound of coal, with average firing, will evaporate from 7½ to 8 lb. of water per hr., but to be safe we will assume that 1 lb. of coal will evaporate 7½ lb. of water per hr.

Grate Surface

Therefore, if the 3000 lb. of water evaporated per hour is divided by 7½, it will show that 400 lb. of coal per hour will be used to evaporate the water necessary to develop 100 boiler horsepower. With a good draft, proper combustion and clean tubes it will require 1 sq.ft. of grate surface to consume 12½ lb. of coal per hour. To find the necessary grate surface, divide 400 lb. of coal consumed each hour by 12½, which calls for 32 sq.ft. of grate surface to consume the necessary fuel.

A mistake is often made by not having space enough between the grate and the bottom of the shell. In designing a furnace for a 100-hp. boiler, the grates should be placed at least 32 in. from the bottom of the shell. Particular attention should be paid to the bridge-wall area. The bridge-wall should be built straight across the furnace and the area between the top of the bridge-wall and the bottom of the shell should equal at least one-fifth of the grate area. A sloping combustion chamber is preferred to a straight one.

Heating Surface

The heating surface of a boiler should be about 40 times greater than the grate surface; in other words, 1 sq.ft. of grate surface is sufficient for 40 sq.ft. of heating surface. Therefore, multiplying 32 sq.ft. of grate surface by 40, will call for a boiler having a total heating surface of 1280 sq.ft. to develop 100 hp.

Tests have shown that an inside tube area equal to one-eighth of the grate surface is sufficient to carry the gases of combustion to the chimney. Multiplying the 32 sq.ft. of grate area by 144 will give 4608 sq.in.; dividing this result by 8 will give 576 sq.in., which is the area required through the tubes. The tubes most commonly used are 3-in. outside diameter and are nearly ⅛ in. thick. Assuming the inside area to be 6 sq.in., divide 576 by 6, which will give 96 tubes 3 in. in diameter.

These tubes will go in a 66-in. boiler and allow sufficient steam space, good spacing of tubes and a 2½-in. vertical space in the center and no tube closer than 3 in. to the shell. This spacing would also allow a manhole below the tubes.

In order to find the length of the tubes and boiler it is necessary to find the heating surface of all the tubes for 1 ft. in length, also two-thirds the circumference of the shell for 1 ft. in length.

A 3-in. tube, 1 ft. long, has approximately 0.75 sq.ft. of heating surface. Then 0.75 multiplied by 96 equals 72 sq.ft. of heating surface in all the tubes for 1 ft. in length. Two-thirds of the circumference of the shell for 1 ft. in length is approximately 11 sq.ft., which added to 72 sq.ft. of tubes gives 83 sq.ft. of heating surface for the shell and tubes for 1 ft. in length. Neglecting the heating surface of the tube sheets, the total heating surface is 1280 sq.ft. Then divide the total heating surface, 1280 by 83 sq.ft., which equals 1 ft. of heating surface in the length of the tubes and shell which gives the length of tubes and boiler as approximately 15 ft. 6 in. If the boiler is to be made with a flush front, it will be 15 ft. 6 in. long and contain 96 three-inch tubes at the same length. If the boiler is to have an overhanging front it will be necessary to have an 18-in. dry sheet for the smoke box, making the boiler 17 ft. long. Having determined the size of the boiler, it is necessary to decide on the material and pressure to be carried.

Boiler Plate

The Massachusetts boiler law requires shell plates to be made of fire-box steel and, as a boiler shell has nothing but its own cylindrical form and strength to sustain the pressure, the best fire-box steel should be used. The boiler is to be built for a working pressure of 150 lb., therefore, the longitudinal joints will be a quadruple-riveted butt joint with inside and outside covering straps, the joint to have an efficiency of 94 per cent. To determine the thickness of the shell, assuming a tensile strength of 58,000 lb. and a factor of safety of 5, which is none too low, and an efficiency of 94 per cent. We then have

$$\frac{\textit{Tensile strength}}{\textit{Radius} \times \textit{factor of safety}} \times \textit{efficiency} = \frac{58{,}000}{33 \times 5} \times 0.94 = 330.41$$

Dividing 150 lb. pressure by 330.41 will give the thickness of plate necessary, or 0.454, or a $\frac{15}{32}$-in. plate. Assuming that the height from the top row of tubes to the shell is 22 in. and using the Massachusetts boiler rules in calculating the segment, which is

$$\frac{4\,H^2}{3} \times \sqrt{\frac{2\,R}{H} - 0.608}$$

equals area of segment to be stayed, in square inches. Where

H = Distance from tubes to shell, minus 5 in.;

R = Radius of shell, minus 3 in.

The segment will contain 658 sq.in., which at a pressure of 150 lb. you will have

$$658 \times 150 = 98{,}700 \textit{ lb.}$$

total pressure on that portion of the two heads.

Braces

A good weldless brace will have 7500 lb. tensile strength

per square inch up to and including 1¼ in. diameter or equivalent, and above that 8000 lb. can be safely allowed. Assume that a 1¼-in. brace is used, having a cross-sectional area of 1.227 in., then 9202 lb. can be allowed for each brace. Dividing the total load on the heads by 9202, it will be seen that more than ten braces are required, therefore, 11 braces will be used on each head.

The rivet strength of the braces must be in excess of the tensile strength of the brace and all braces should be located so as to have as direct a pull as possible and no brace should be less than 46 in. in length.

Fittings

As regards the nozzles, avoid cast iron as much as possible and use cast- or pressed-steel nozzle. Safety-valve and steam-pipe outlets should be separate and if a dry pipe is used, the safety-valve outlet should not be connected to it. The blowoff flange should be of pressed steel. To complete the boiler the necessary castings must be obtained, besides the brick work and foundation, viz., the front, grates, dead plate, arch and check plates, buckstays and rods, anchor bolts, clean-out doors not less than 16x20 in., stack base and stack or chimney, also breeching to chimney, damper located in the breeching, wall plates and rollers or, if preferred, instead of rollers under the lugs use iron balls 1½ or 2 in. in diameter. This will allow the boiler to expand freely in all directions.

The necessary fittings are 3½-in. pop safety valve, steam gage graduated at least 1½ times the allowed boiler pressure, check and feed valves. The blowoff valves should be 2 or 2½ in. in diameter. Then there are the water column and connections. Have the lower connections of brass and use cross fittings instead of elbows, so that in case the lower connections should fill up with scale, the plug in the cross can be removed and the pipe cleaned with a rod.

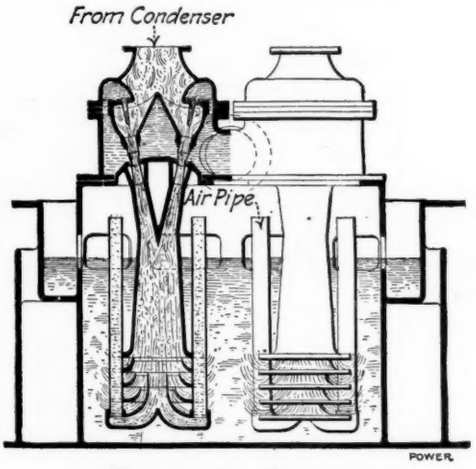
A surface blowoff to rid the boiler of scum is advisable because in so doing the scale-forming impurities are removed, for scale is nothing but floating matter and scum which finds its way to the tube and shell surface where it adheres, but it can be blown out very easily with a surface blowoff while the boiler is in operation. Provide the boiler with two methods of feeding and do not forget a good, closed heater; it will pay for itself in less than a year and if a closed heater is used, no grease can get into the boiler.

Chicago to Have a 30,000-Kw. Turbine

The Commonwealth Edison Co., of Chicago, has recently ordered a 30,000-kw. turbo-generator for its Northwest Station. In the Fisk St. extension they are installing at present a 25,000-kw. Parsons turbine, and have also ordered a 20,000-kw. horizontal turbine from the General Electric Co. The 30,000-kw. machine for the Northwest Station will also be of the General Electric horizontal type and similar to the unit for Fisk St., with the exception that the turbine will be designed with separate high- and low-pressure cylinders, the latter being arranged on the double-flow principle. The larger unit will be somewhat more economical in steam consumption. It will be equipped with a surface condenser having 50,000 sq.ft. of cooling surface, together with necessary auxiliaries, and a boiler equipment similar to the new units at Fisk St., described in the issue of Nov. 4 and on other pages of this issue. The generator, at a speed of 1500 r.p.m., will have a continuous full-load rating of 30,000 kw. at 100 per cent. power factor. Current will be generated at 9000 volts, 25 cycles. The exciter will be direct connected to the main generator shaft and will furnish current at 250 volts.

Kinetic Air Ejector

For the removal of air and noncondensable vapor from a condenser, the kinetic air ejector is a radical departure taking the place of the so called dry-vacuum pump used in a great majority of large condenser installations in this country. The particular ejector illustrated herewith was furnished by Messrs. Richardsons, Westgarth & Co., of West Hartlepool, Eng., for the condenser of the large 25,000-kw. Parsons turbine now being installed at Fisk Street Station, Chicago. It will be remembered



Kinetic Air Ejector

that this turbine and its condenser were described in our issue of Nov. 4. The ejector illustrated is made up into two units which can be used independently or together.

The ejector comprises a set of water jets annularly arranged which entrain the air and noncondensable vapors, removing them from the lower part of the steam space of the condenser. Water is pumped through these jets under a pressure of about 35 lb. per sq.in., by a centrifugal pump. The water is taken from the kinetic tank and from the nozzles discharged back to it, carrying the air with it on its return. Another centrifugal pump takes the water of condensation from the condenser and discharges it into the kinetic tank. The core of air formed in the column of water after entering the ejector is caught by a collecting pipe, by which it is discharged above the water level in the tank, and so obviates aëration of the feed water. Between the condenser and the kinetic nozzles there is a steam ejector which is used to augment the vacuum. This is not shown in the accompanying drawing, but appears in the article of Nov. 4.

The kinetic tank consists in reality of three sections; the middle section constitutes the kinetic tank proper, which has just been referred to. In addition to this, there is a tank on one side which performs the function of a feed-water heater and on the other side is a hotwell from

which the feed pumps take their supply. The hotwell is provided with a float connected to the makeup water supply, so that an adequate quantity of water will be maintained for boiler feed. The kinetic tank proper has an outside chamber into which the water overflows from the central chamber containing the nozzles. The water passes through a number of copper strainers and from this section flows to the feed-water heater. The water is heated by a number of steam jets whch are supplied with steam from the connection between the high- and low-pressure cylinders on the turbine, or from the steam-driven boiler-feed pump. The heater section is connected to the hotwell by a passage running through the bottom part of the kinetic tank.

Should the supply of water in the hotwell tank be more temporarily than the demands of the boiler-feed pump, the excess will pass out through an overflow pipe which runs into a large reservoir located below the level of the basement floor. The use of this reservoir serves to save the pure water of condensation, which would otherwise be wasted. When the supply in the hotwell becomes deficient, a float valve in the hotwell serves to establish a connection from the reservoir into the condenser, thus furnishing the necessary makeup water. An additional float valve in the large reservoir serves to maintain the level at a predetermined height and admits water from the filtered water system in the station.

A number of official tests on the kinetic plant for the Commonwealth Edison Co. were made under the direction of Messrs. Merz & McLellan, of Newcastle-on-Tyne, Eng.

For the test the air-suction pipe was blanked off. The desired vacuum was maintained, and a known quantity of free air was admitted to the suction system through calibrated nozzles, with the same quantity of water at specified temperature passing through the pump as will pass through when it works in connection with the actual condenser. A remarkable feature in the results was that a vacuum of 29.8 in., with a barometer of 30 in., was maintained with an air admission of 14 cu.ft. per min., the temperature of the water passing through the jets being 74 deg. As 36 deg. is the temperature corresponding to a vacuum of 29.8 in., the water was actually 38 deg. warmer than the air. With an air admission of 160 cu.ft. per min., a vacuum of 28.6 in. was maintained with water at 85 deg. passing through the jets.

In some special tests made to determine the effect on the air withdrawing capacity of high-temperature water passing through the jets, it was found that 29 in. vacuum could be maintained with water at 130 deg., the air admission being 96 cu.ft. per min. The temperature corresponding to 29 in. of vacuum is 79 deg., so that the water was 51 deg. warmer than the air. Such a temperature is beyond what may be expected in practice, but the test well illustrates the flexibility and range of the apparatus.

❖ ❖

Steam Regenerative Accumulators

By H. Fothergill

Although steam-regenerative accumulators have been *high-pressure intermittent running reciprocating engines and low-pressure steam turbines; some features of design and a description of the Rateau-Morison type.*

❖

Although steam-regenerative accumulators have been employed in principle for at least 30 years, their practical use has been successful only since the advent of the low-pressure steam turbine.

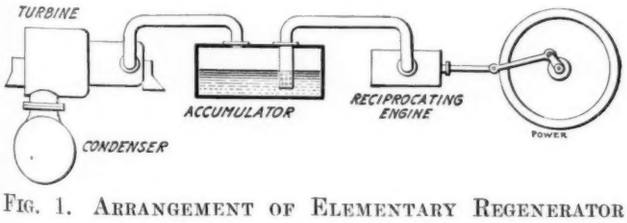


Fig. 1. Arrangement of Elementary Regenerator

The application of the system lies chiefly in combining the steam turbine with intermittent running reciprocating engines, such as are used in rolling mills, colliery winding engines, etc., where the use of a continuous running high-pressure turbine as a substitute for the reciprocating engine would be impracticable. The exhaust steam from an intermittent running reciprocating engine cannot be used directly in a turbine as the exhaust is delivered in gulps which must be changed into a continuous supply at approximately uniform pressure. This transformation is effected by means of a steam-regenerative accumulator. Broadly speaking, a steam-regenerative accumulator is an apparatus which absorbs heat from steam delivered to it in intermittent quantities and gives up heat in the form of a continuous supply of steam of slightly lower pressure than the steam received.

When a steam turbine is supplied with exhaust steam from a high-pressure engine, such as a colliery winding engine, the quantity of exhaust discharged by the winding engine is at times greater than is required for driving the turbine, and it is the object of the regenerative accumulator to store up the heat in this surplus steam by condensing it in a body of water which gives it out again in the form of regenerated steam when the supply from the engine is insufficient for the turbine.

The system is illustrated diagrammatically in Fig. 1. Exhaust steam from the reciprocating engine passes into the water by which it is condensed, the water being thereby heated. When the water is raised to the same temperature as the exhaust steam, the steam passes through the water to the steam turbine, and when the supply of exhaust steam ceases, the turbine by continuing to draw from the steam space reduces the pressure and causes the water to boil, whereby a supply of regenerated steam continues to pass to the turbine; the water being again raised in temperature every time exhaust steam is delivered from the reciprocating engine.

There are several disadvantages in accumulators wherein the whole of the exhaust steam passes into the water. For example, there is a constant difference between the pressure in the exhaust-steam supply pipe to the accumu-

lator and the pressure in the outlet pipe from the accumulator to the turbine, the pressure difference being equal to the resistance offered by the head of water in

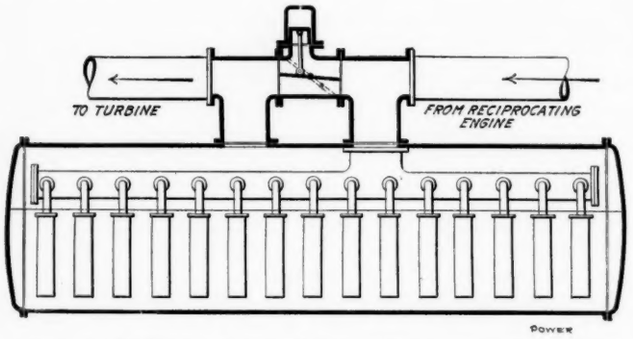


FIG. 2. PART OF STEAM PASSED DIRECT TO TURBINE

the accumulator through which the steam must be passed. This resistance causes a drop between the initial pressure at the turbine and the pressure in the exhaust-steam supply pipe to the accumulator. This drop is equivalent to a loss of energy. Again, when the whole of the exhaust steam must pass into the water, the first effect produced by the exhaust steam is the gradual heating and the gradual evaporation of the water in the accumulator. This continues until the temperature of the water in the accumulator corresponds to the steam pressure which is necessary for driving the turbine, the response of the turbine to the supply of exhaust steam from the reciprocating engine at starting is therefore delayed.

The writer has found from experiment that higher efficiency is obtained if a controllable portion of the exhaust steam from the reciprocating engine is passed direct to the steam turbine as illustrated in Fig. 2. It will be seen from this that the exhaust-steam supply pipe to the accumulator is connected to the steam-supply pipe to the turbine by a valve that is operated by a piston controlled by the pressure of the exhaust steam from the reciprocating engine, so that under normal conditions the valve is open, but when a predetermined pressure is exceeded the piston is forced upward and the valve closed. Therefore, at all pressures below that corresponding to the resistance offered by the head of water above the nozzles in the accumulator, the steam flows freely to the turbine so that the loss of pressure which must result where the entire steam passes into the water, is avoided. Also, when starting, a portion of the steam which flows past the control valve fills the steam space of the accumulator and raises the pressure considerably above that corresponding to the temperature of the water in the accumulator; consequently all the heat in the steam supplied through the nozzles is absorbed by the water and no evaporation takes place until its temperature reaches the temperature corresponding to the pressure in the steam space. This rapid absorption of heat by the water in the accumulator in addition to and in parallel with the supply of steam to the turbine through the control valve causes a total consumption of steam in a given time greater than in the ordinary system. This greater consumption takes place just at the time when the maximum quantity of steam is discharged by the reciprocating engine and as a consequence the loss of surplus steam through the safety valve is minimized.

In the working of a colliery winding engine, the period of acceleration is about one-fifth the total period, so that during acceleration the amount of exhaust steam may be many times the average and drop off to nothing before the winding is completed. In rolling-mill work the effect is similar, but the periods are shorter. The duration of the stops to be bridged varies for different services, but in the majority of cases may be taken at 60 sec. in colliery work, and from 30 to 45 sec. in rolling-mill work.

The pressure range over which an accumulator is designed to work is usually taken from 17 to 14 lb. per sq.in. absolute, corresponding to a temperature range of 10 deg. F. so that the pressure in the accumulator will be continually varying from above atmospheric pressure to slightly below, there being periods of pressure and periods of partial vacuum, the partial vacuum never exceeding 3 in., thus leaving a minimum range of from, say, 3 to 28½ in. in the turbine, while at times the pressure at the turbine inlet may be 2 lb. above atmospheric.

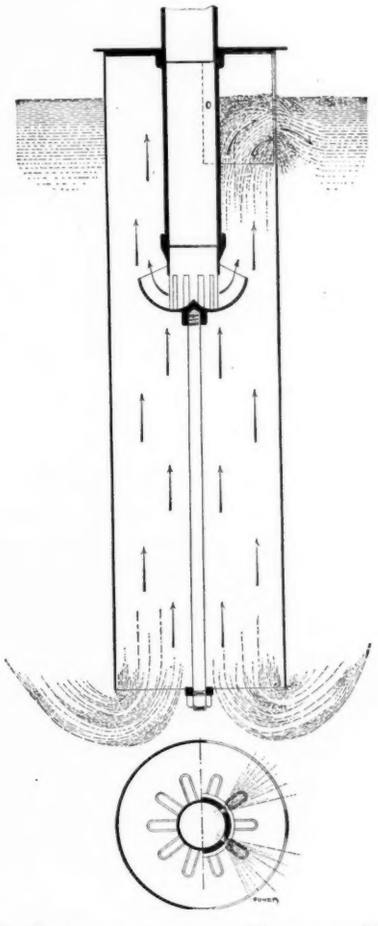


FIG. 3. SECTION THROUGH EXHAUST NOZZLE

The calculations for a steam-regenerative accumulator are comparatively simple.

Let,

W = Pounds of steam required per second for the turbine;

w = Pounds of water in the accumulator;

T = Time of stop in seconds when the reciprocating engine is not working;

t = Temperature rise in the accumulator water,

usually about 10 deg. F.;

H = Total heat per pound of steam in the accumulator, above the temperature of the water, which equals approximately the latent heat.

Total heat of steam regenerated from the water during stoppage of reciprocating engine = WTH.

This quantity of heat has to be stored by the water in the accumulator.

Total heat stored by the water = wt.

Hence, $$WTH = wt$$

$$w = \frac{WTH}{t}$$

From this equation it is seen that the capacity is independent of the time of absorption; but in order to obtain maximum efficiency it is necessary for the whole body of contained water to be at a uniform temperature when regeneration commences. Therefore, in order closely to approach this ideal result, a very effective method of circulating the whole mass of water must be adopted.

It has been found by employing multiple heating nozzles so constructed that the surplus steam is discharged from them in narrow sheets in an upward direction, that steam is easily condensed by the surrounding water and at the same time produces maximum circulation through the pipes in which they are placed. In this way the large volume of steam coming from the high-pressure engine is so divided up and distributed throughout the accumulator that the disturbance caused by the hot steam meeting the water is practically of no account and this permits the steam outlets to be placed very close to the surface of the water without causing any violent ebullition on the surface and producing priming or wet steam. A great advantage obtained by reducing the depth of water above the steam outlets, is that the resistance to flow through the nozzles is correspondingly reduced.

After exhaustive tests involving a large number of designs the arrangement of nozzle placed within a vertical circulating tube, as shown in Fig. 3, has been adopted in the Rateau-Morison accumulator.

In plan the nozzle is in the shape of a star having radial arms, each of which is provided with a narrow slot on its upper surface through which the steam passes in films, thereby exposing a large surface to the upwardly induced streams of water that flow between the arms. The nozzle is placed about 9 in. below the water level,

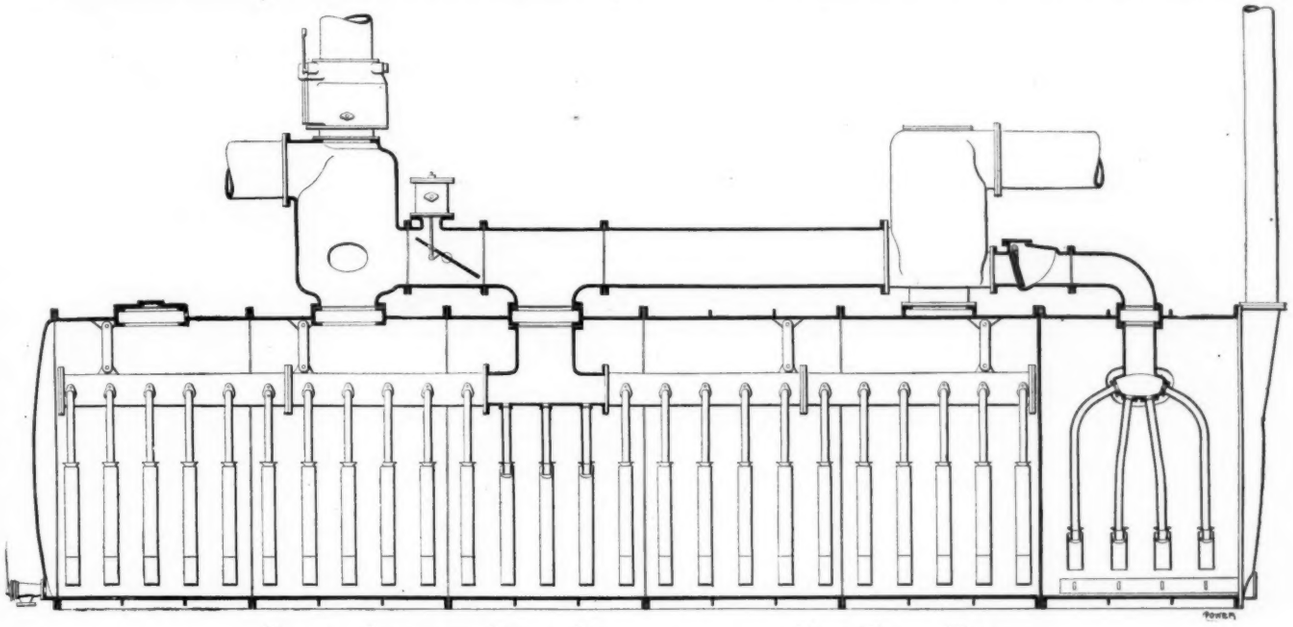


FIG. 4. COMBINED STEAM REGENERATOR AND FEED-WATER HEATER

and the steam supply is by a tube connected to the main steam-supply pipe which is situated in the steam space of the accumulator. There can be no short-circuiting of the water with this arrangement, as the entire volume within the effective range of the tube is compelled to travel from the bottom to the top.

In the practical working of accumulators the presence of oil on the water has been found to have a detrimental effect. It will be noted that the circulating device illustrated in Fig. 3 is provided with a water outlet at the top at one side only, and as the discharge from each water-circulating device is in one direction, viz., toward the end of the accumulator, a current is set up which continuously and effectively forces oil, scum and all floating impurities toward one end into a collecting chamber, from which it is drained away periodically or continuously as may be desired.

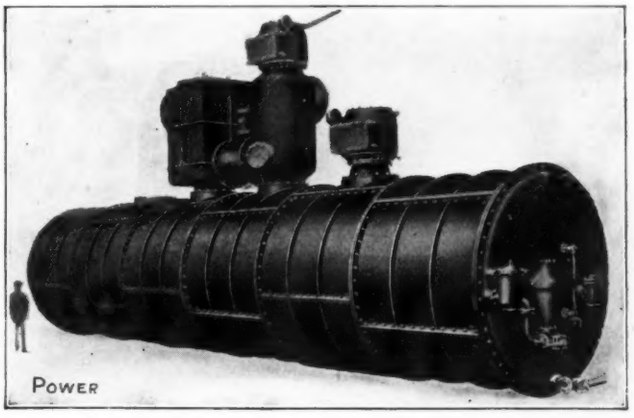


FIG. 5. EXTERIOR VIEW OF RATEAU-MORISON ACCUMULATOR

In combined reciprocating-engine and steam-turbine plants wherein the supply of exhaust steam is considerably greater than that required by the turbine, a very convenient way of utilizing the surplus steam is for feed-water heating. Fig. 4 shows in section a combined steam-regenerative accumulator and feed-water heater. The heater is placed at the right-hand end of the accumulator and is connected by a nonreturn valve to the exhaust-steam supply system, the nozzles in the heater being submerged at a much greater depth than the nozzles in the accumulator, so that the exhaust steam preferentially flows through the nozzles in the accumulator but when there is a surplus supply, then the pressure rises and steam passes through the nonreturn valve into the heater.

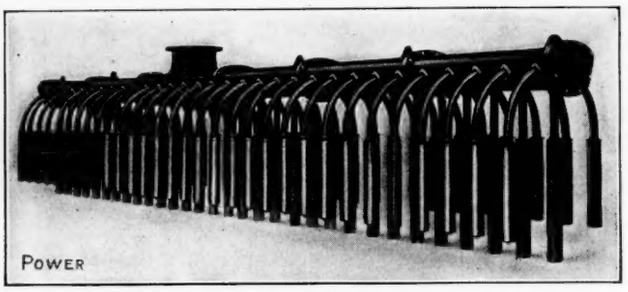


FIG. 6. INTERNAL WATER-CIRCULATING TUBES

Fig. 5 is a photograph of a modern accumulator of the Rateau-Morison type. On the top of the accumulator are shown the exhaust-steam inlet, oil-separating chamber, bypass valve, outlet dome and safety valve, and Fig. 6 shows the internal water-circulating tubes.

Test of a Welded Boiler

In connection with our report of the convention of the N. A. S. E. we mentioned briefly a test made by The Welding Co. of Springfield, Mass., of a rivetless boiler. We are able now to present reproductions of photographs of the boilers as taken under test by A. D. Risteen, of the Travelers' Insurance Co. It is of the vertical firebox type, designed to carry only 10 lb. pressure, 30 in. in diameter, made of ¼-in. flanged steel, and put together by oxyacetylene welding. Fig. 1 shows the longitudinal joint; Fig. 2 shows how the head or upper tube sheet

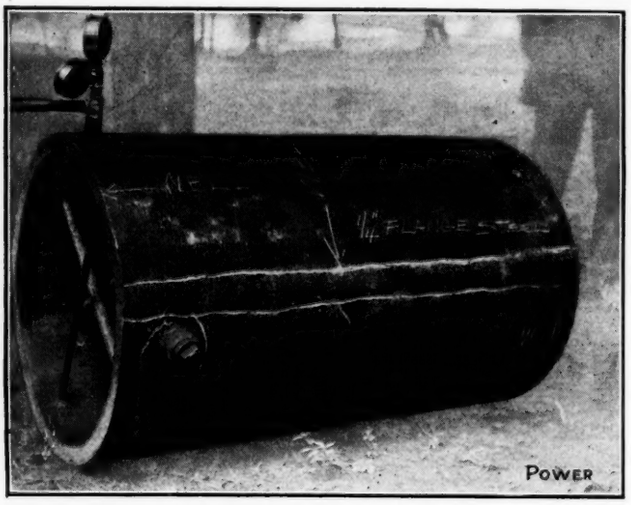


FIG. 1. WELDED LONGITUDINAL SEAM

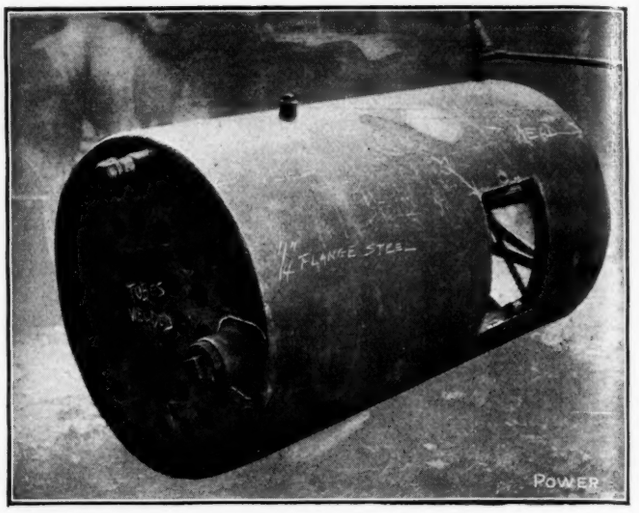


FIG. 2. TUBE SHEET WELDED IN

and door frame are welded in. On account of the low pressure for which the boiler is designed the water leg was not stay-bolted, and to oppose the tendency of the inner sheet to bulge under the high pressure of the test, it was braced by rods placed irregularly in the firebox which was 26 in. in internal diameter and 24 in. in height. These rods were not, however, so arranged as to

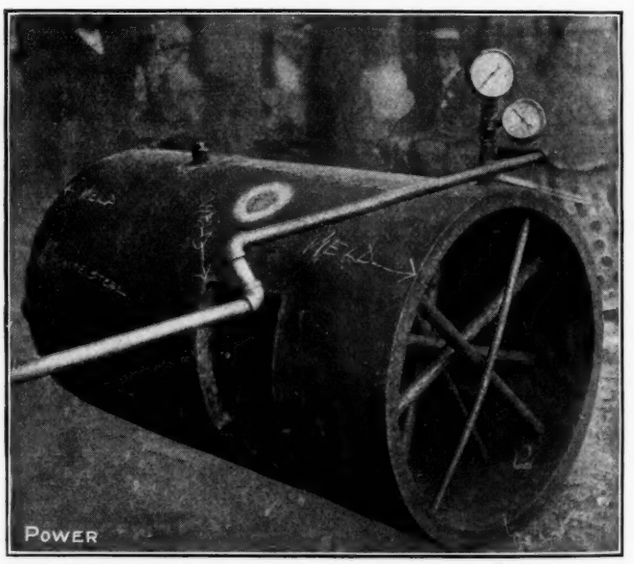


FIG. 3. FIREBOX END, SHOWING TEMPORARY BRACING

prevent distortion, and at 310 lb. the inner sheet of the water leg had bulged inward so badly that it tore away from the door frame and allowed a leak which made it impossible to carry the pressure higher. The longitudinal and other seams stood the pressure perfectly. It is proposed to stay-bolt the water leg and repeat the test under conditions which will put the welding itself to the test.

To Regulate the Price of Water Power to consumers, the national government has established a new policy in granting water-power permits. A maximum charge of 6c. per kw.-hr. is fixed by the terms of the permit, and the lower the power rate charged by the company, the lower will be the water rate collected by the government. Lower rates on water are to be charged for power used for certain purposes, such as making nitrates for fertilizers, and decreasing rates as more power is developed. This will not only protect the consumer, but encourage the fullest development of water power.

ELECTRICAL DEPARTMENT

The Induction Motor—III

By F. A. Annett

Wound Rotor

At the instant of starting, the simple squirrel-cage induction motor acts very much like a potential transformer with the secondary short-circuited; that is, when the rotor is at rest the electromotive force induced in it is at a maximum and the frequency is the same as the stator winding, consequently, since the resistance of the rotor is low the current will be large at a low power factor, causing the stator winding to take a large current from the line with a correspondingly low power factor.

The starting torque of an induction motor is influenced to a very large degree by the angle of lag between the current and the e.m.f. in the rotor, being at a maximum when the two are in phase and at zero when the current is lagging 90 deg. Since the phase relation between the current and the e.m.f. in an alternating-current circuit depends upon the resistance and the reactance of the circuit, the two being nearly in step when the reactance is small and the resistance high and differing in phase nearly 90 deg. when the reactance is high and the resistance low, it is evident that to provide a good starting torque the resistance of the rotor should be high and the reactance low; but high-resistance rotors decrease the efficiency of the motor when running, therefore, to get the best operating results the rotor should have high resistance at starting and low resistance when running. This condition is frequently secured by the use of a wound rotor connected to an external resistance, a motor of this type permitting easy speed adjustment as will be explained later.

This type of rotor instead of being wound with bars which are short-circuited at each end as in the squirrel-cage type has a winding of insulated wire similar to the winding used on the armature of a three-phase alternator, the polar spacing depending upon the polar spacing of the stator winding. This winding is connected in series with an external resistance at starting which is cut out as the rotor comes up to speed.

It is well known that the torque of a wound-rotor motor fluctuates greatly, depending upon the position of the rotor winding with respect to that of the stator. This fluctuation increases as the current increases and the smaller the number of phases in the rotor. For this latter reason the three-phase winding is used exclusively on the rotors of all polyphase wound-rotor induction motors whether the motor is built for a two-phase or a three-phase circuit. This fluctuation is also present in the squirrel-cage motor, but to a very small degree as the number of phases in the rotor is very great.

Wound rotors are built in two general types, those that have the starting resistance and short-circuiting switch mounted within the rotor, and those that have the starting resistance and cutout switch mounted outside the motor.

Fig. 19 shows a G. E. wound rotor in which the resistance is mounted on the spider. The resistance is made in three parts, one part for each phase, and consists of cast-iron grids inclosed in a triangular frame which is bolted to the end plates holding the rotor laminations together. It is short-circuited by sliding laminated spring metal brushes along the grids. These brushes are supported by a metal sleeve upon the shaft which is operated by a rod that passes through the end of a hollow shaft and engages the brush arrangement in the rotor. The outer end of this rod terminates in a loose knob as shown, and by pushing in the knob when the motor has attained its speed the resistance is cut out. In the larger-sized motors the resistance is cut out by a lever secured to the bearing bracket. These resistances are made in three different forms: Cast-iron grids, cast-brass grids and cylindrical coils made from a german-silver strip wound on its edge. In all three forms the resistance is cut out in a way similar to that explained.

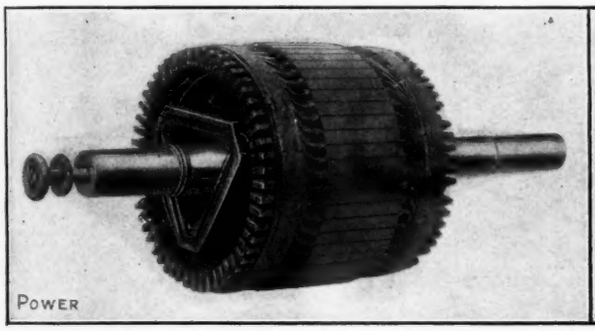


Fig. 19. G. E. Wound Rotor

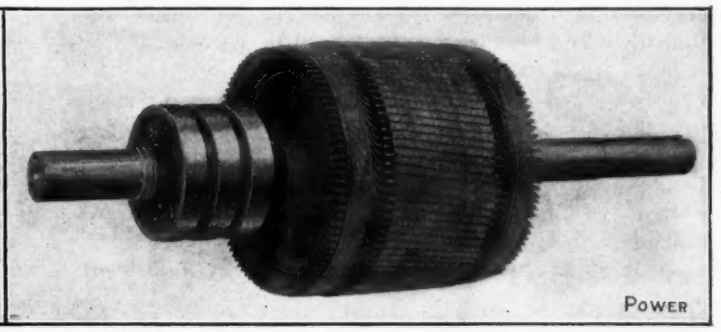


Fig. 20. Rotor Having External Resistance

If the resistance is to be cut out at a distant point from the motor, or the motor is to be used for variable-speed service it is best to mount the resistance and controller external from the motor. This necessitates the use of three collector rings, insulated from each other and keyed to the shaft. Fig. 20 shows a G. E. rotor of this type. These collector rings connect the rotor winding to the controller and resistance through brush gear provided for that purpose.

Fig. 21 shows diagrammatically the rotor winding connected to the starting resistance through the collector rings and brushes. The three rotor windings A, B and C are connected in star, and the terminals of the windings are connected to the three collector rings. The three branches R_1, R_2 and R_3 of the starting resistance are also connected in star by the three-armed short-circuiting switch S. At starting the arm is in the position shown by the full lines and all the resistance is in series with the rotor winding. As the rotor comes up to speed the arm is gradually moved around in the direction indicated to the position shown by the dotted lines. At this position the resistance is all cut out and the three rotor windings are short-circuited by the arms of the switch. By using three resistances, one in each phase of the rotor, and a short-circuiting switch, as shown in Fig. 21, the resistance in each phase is kept balanced, and, consequently, the current for the different starting points, although this is not absolutely necessary except at the point of maximum starting torque.

In most cases satisfactory starting can be obtained by using what is known as an unbalanced resistance, as shown in Fig. 22. Two resistances R_1 and R_2 are connected in open delta at starting by the arm S in the position shown by the full lines, as the motor comes up to speed the arm is gradually moved around to the position indicated by the dotted lines at which position the resistance is all cut out and the rotor windings are short-circuited. With such a connection the current in phase C is greater than in phases A and B for all starting points, the current in each phase becoming nearer balanced as the resistance is decreased until the rotor windings are short-circuited, at which point the conditions are the same as in Fig. 21. This unbalancing of the current has so little effect that it is unobjectionable for most starting purposes.

The Bell Electric Motor Co. manufactures an interesting type of polyphase induction motor, the rotor of which has a high resistance at starting and a low resistance when running. A winding similar to that used on the armature of a direct-current motor is placed in the bottom of the rotor slots and connected to a commutator, as there is no external circuit provided for this winding no current will be set up in it at starting. A second winding similar to a squirrel-cage winding of high resistance is placed in the top of the slots. At starting this winding acts like that of a regular squirrel-cage motor except on account of the high rotor resistance the starting current taken from the line is considerably reduced, and the starting torque increased. When the rotor comes up to speed a short-circuiting device mounted on the shaft at the outer end of the commutator is thrown in by a centrifugal governor and short-circuits the coils of the winding in the bottom of the slots through the commutator, making this winding similar to the squirrel-cage winding and thus reducing the resistance of the rotor. At running the rotor is similar to one that has two squirrel-cage windings in parallel. The commutator is used for no other purpose than to provide a ready means to short-circuit the winding, thus making the motor automatic in its starting and requiring no attention other than closing the line switch at starting and opening it again when the motor is stopped.

The Wagner Electric Manufacturing Co. builds a wound-rotor polyphase induction motor that is also automatic in starting. The rotor winding is similar to that used on a direct-current armature and is connected to a vertical commutator, this winding is so connected that the coils are in series at starting and thus increase the rotor resistance. After the rotor has attained the proper speed a short-circuiting device mounted within the rotor is thrown in by a centrifugal governor and the rotor is then running as one of the squirrel-cage type. The stator winding is the same as that used in any polyphase motor. This type of motor is well adapted to remote control, requiring no controlling device other than a single-throw three-pole switch to open and close the line circuit and a double-throw switch if the motor is to be reversed.

To Reverse the Direction of Rotation

To reverse the direction of rotation of a two- of three-phase induction motor it is necessary to reverse the direction of the revolving magnetic field. In a two-phase motor this can be done by crossing the terminals of either phase with the terminals of the motor, and a three-phase motor can be reversed by crossing any two terminals. The following diagrams will make this clear:

Fig. 23 represents a two-phase induction-motor winding connected to a four-wire, two-phase circuit; crossing the connection of phase A or B, as shown in Fig. 24, will reverse the direction of rotation. Fig. 25 represents a two-phase motor connected to a three-wire, two-phase circuit. The voltage E across each phase is the same, but between the two outside legs it is $E\sqrt{2}$. The motor under this condition can be reversed in two different ways, first as shown in Fig. 26, by crossing either of the phase terminals in the motor, which leaves the connections with respect to the e.m.f. as they were at first. The second method is shown in Fig. 27 and consists in

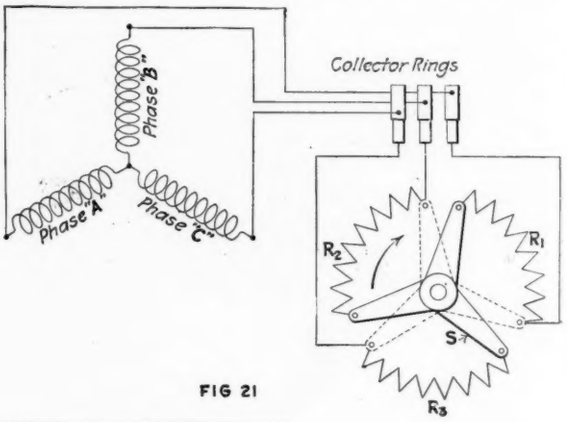


FIG 21

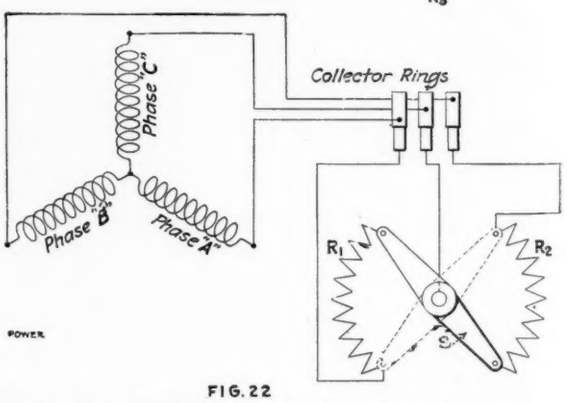
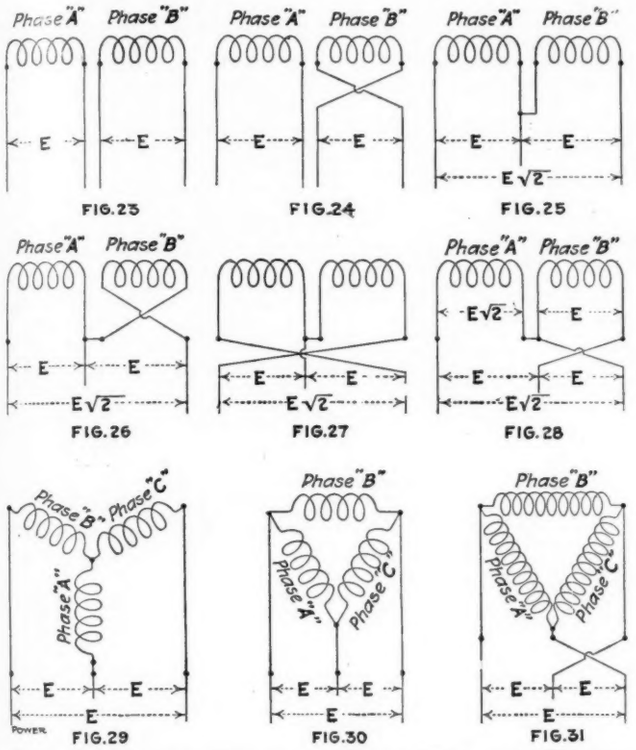


FIG. 22

BALANCED AND UNBALANCED STARTING RESISTANCES

crossing the outside line terminals. This gives the same voltage relation with reference to the two different windings, that is, there is E volts across phases A and B and $E\sqrt{2}$ across the two outside terminals. Care should be taken not to connect a two-phase motor, as shown in Fig. 28, as this gives an excessive voltage across one phase which changes the phase relation of the current in the



CONNECTIONS FOR REVERSING BOTH TWO- AND THREE-PHASE MOTORS

two windings and reduces the starting torque, also the excessive current is liable to burn out the windings in a very short period.

In Fig. 29 is shown diagrammatically the windings of a three-phase motor connected in star to a three-phase circuit. The voltage is the same between any two-line wires, and between any two terminals of the motor there are two windings connected in series. Hence, any two of the line terminals can be crossed with respect to the motor terminals and have the same relation between the line voltage and the windings in the motor. This also holds true for the delta connection shown in Fig. 30; in this connection, however, there is only one winding across each phase and to work on the same voltage as the star connection will require seven-tenths more turns in each winding than required when the windings are connected in star. Crossing any two of the line terminals, as shown in Fig. 31, with respect to the motor terminals will reverse the direction of rotation.

❖

Occupation of Graduate Engineers—In an interview published in the "New York Times," Oct. 18, Professor Furman of the Stevens Institute of Technology reviews the careers of graduates of that school of mechanical engineering and furnishes diagrams showing that of men graduated 15 to 20 years, about 42 per cent. are filling positions as executive officers, managers, etc.; about 18 per cent. occupy executive positions as superintendents and heads of manufacturing departments and about 5 per cent. are retired or unaccounted for.

Necessity for Good Voltage Regulation

BY CORNELIUS WEBER

The importance of good voltage regulation will be apparent from the following few facts which point out the financial loss encountered by line drop or a high-reading voltmeter.

Assume, for example, that a central station in a small town serves 800 incandescent-light customers and that the average kilowatt-hour consumption per customer per month is 20. This corresponds to an average burning of four 40-watt lamps for 4 hr. each evening, a total of 512 kw.-hr. per night with normal voltage at 110. This kilowatt-hour consumption per evening amounts to 188,800 kw.-hr. per year and, at 10c. per kw.-hr., represents the sum of $18,880.

Now suppose that, due to line drop or a high-reading voltmeter, or a combination of both, the average actual voltage on the incandescent-lamp circuits is only 105, so that the voltage is 95.5 per cent. of normal. Under these conditions the wattage output is only 91.2 per cent. of normal, as the wattage input on resistance loads such as incandescent lamps varies as the square of the voltage. In other words, this loss of five volts causes a loss of 8.8 per cent. in kilowatt-hour consumption and, in the foregoing example, represents $0.088 \times 18{,}880 = \$1661.44$. This decrease in revenue is practically a total loss.

Electric cooking utensils, flat-irons, etc., behave in a similar manner to incandescent lamps and when operating below normal voltage cause losses in revenue in the same way. This is not true, however, of electric motors, as these have, for a given load, practically a constant wattage input even with varying voltage within reasonable limits. However, motors are often the cause of heavy line drop and it is good practice as a rule to keep power and lighting circuits separate.

Aside from the actual financial loss caused by low voltage the lamps suffer a decrease in candlepower and efficiency. A 110-volt carbon-filament lamp burning at 105 volts or 95.5 per cent. normal voltage delivers only 74 per cent. of the normal candlepower while under similar conditions the tungsten lamp delivers about 83 per cent. normal candlepower. This readily accounts for dissatisfied customers and loss of business.

A well designed distributing system is invariably a well paying investment and station instrument inspection and calibration a matter of no little importance.

❖

Voltage Too High

We have three Westinghouse turbines direct-connected to alternating-current generators running at a speed of 3600 r.p.m. Two of the machines show a voltage of 2300 at 60 cycles, while the other one shows 2350 at 60 cycles. Now in trying to get the voltage down to 2300 the machine was slowed down to 56 cycles, but this did not make any difference in the voltage, it still being 2350. The rheostat on the machine was then cut in and out to the limit but still there was no change in the voltage.

Perhaps someone can account for this one machine acting in this manner. We have a vibration tachometer on each machine and a Terrill regulator on the system.

WILFORD M. STOCKWELL.

Middletown, Conn.

GAS POWER DEPARTMENT

Exhaust Gases from Oils and Gas Fuels

By Julian C. Smallwood

The proportions of CO_2, oxygen and nitrogen resulting from the combustion of coal are fairly well known, so that one readily forms an idea of the efficiency of the process upon learning the percentage of CO_2. This, however, is not the case when the fuel is any of the fuel oils or gases.

The accompanying curves show the proportions to be expected, as would be indicated by an analysis with the Orsat apparatus, in the products of complete combustion of representative oils and gases using various amounts of air. Curves for carbon, anthracite and bituminous coal are included for comparison. The percentages of CO_2, O_2 and N_2 are shown vertically; and horizontally, the ratio of air used to that theoretically required for complete combustion, that is, the "excess coefficient."

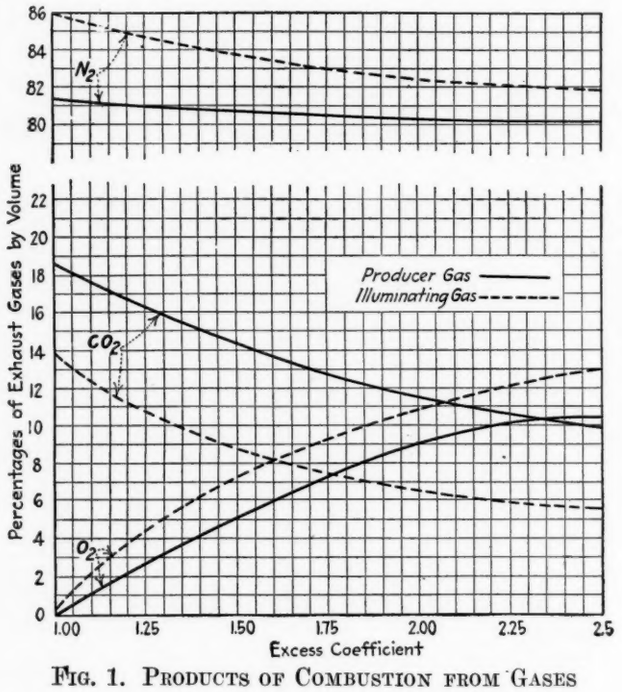


Fig. 1. Products of Combustion from Gases

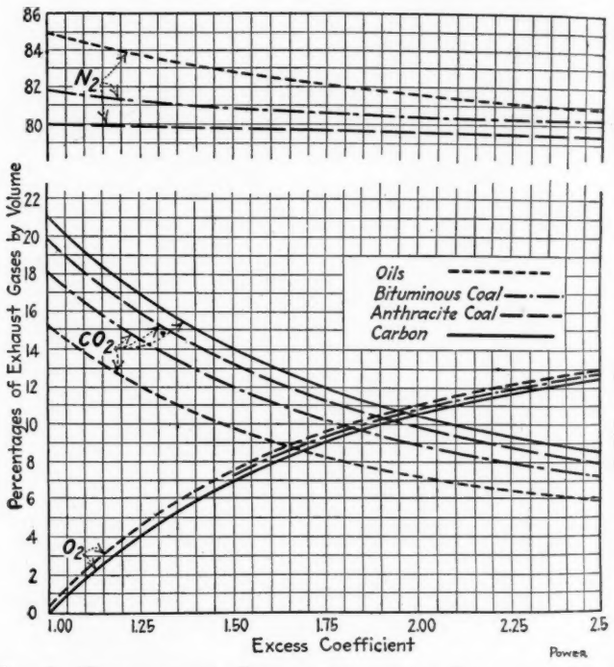


Fig. 2. Products of Combustion from Oils and Coal

The chemical analyses of the assumed fuels are as follows:

	Gas, Per Cent. by Volume		Oil, Per Cent. by Weight	Coal, Per Cent. by Weight	
	Producer	Illuminating		Anthracite	Bituminous
Carbon monoxide, CO	25	15			
Carbon, C			84	89	76
Hydrogen, H_2	12	45	14	2	5
Marsh gas, CH_4	2	25			
Olefiant gas, C_2H_4		3			
Benzol, C_6H_6		2			
Oxygen, O_2		1			
Carbon dioxide, CO_2	5	4			
Nitrogen, N_2	55	5			
Impurities, SO_2, H_2S, etc.	1	.	2	9	19

The constituents of each of these classes of fuels vary widely in proportions, according to manufacture or mine, except those of oil. In the various fuel oils, whether distillates or crudes, the percentages of carbon and hydrogen are remarkably similar, being between 82.5 and 85 per cent. C, and between 12 and 15 per cent. H_2. The products from the complete combustion of oils will therefore be in all cases nearly those shown by the curves for oil combustion. With the other fuels, however, the proportions of the products will vary somewhat according to the differences in the particular fuel analysis from those assumed for the curves.

The products of actual combustion will differ from the results shown by the curves if there is incomplete combustion. Carbon monoxide in the exhaust will lower the percentages of the other gases, and unburned hydrocarbons will appear as nitrogen and lower the percentages of the other products. Since the products of incomplete combustion in good practice are small, their effect to change the theoretical relations is not large.

In many cases it is of value to plot curves similar to those shown, assuming an average value of the fuel analysis. These curves furnish a ready check upon the efficiency of combustion in connection with actual exhaust-gas analyses, and also check the accuracy of the exhaust-gas analyses since any marked variation of the results from the proportions shown by the curves would indicate error.

For this purpose, the following formulas may be used for the combustion of oils and coals. These neglect the effects of the nitrogen, oxygen and sulphur in the fuels

as they are of small amounts and do not swell the products of combustion materially: Let

C = Percentage by weight of carbon in the fuel;
H = Percentage by weight of hydrogen in the fuel;
X = Excess coefficient.

Then, in the exhaust gas,

$$\textit{Per cent. } CO_2 = \frac{C}{C + (4.75\,X - 1)(C + 3\,H)} \times 100$$

$$\textit{Per cent. } O_2 = \frac{(X - 1)(C + 3\,H)}{C + (4.75\,X - 1)(C + 3\,H)} \times 100$$

$$\textit{Per cent. } N_2 = 100 - \%\ CO_2 - \%\ O_2$$

To get the products of combustion to be expected from gas fuels, knowing the volume analyses, one must first calculate the quantities referred to below as c, A and T. Letting % CO, % H_2, etc., stand for the percentages of the fuel-gas constituents, as shown by the fuel-gas analysis,

$$c = \%\ CO + \%\ CH_4 + 2 \times \%\ C_2H_4 + 6 \times \%\ C_6H_6 + \%\ CO_2$$

$$A = 0.5 \times (\%\ CO + \%\ H_2) + 2 \times \%\ CH_4 + 3 \times \%\ C_2H_4 + 7.5 \times \%\ C_6H_6 - \%\ O_2$$

$$T = c + (4.75\,X - 1) \times A + \%\ N_2$$

Then, in the exhaust gas

$$\textit{Per cent. } CO_2 = \frac{c}{T} \times 100$$

$$\textit{Per cent. } O_2 = \frac{(X - 1) \times A}{T} \times 100$$

$$\textit{Per cent. } N_2 = 100 - \%\ CO_2 - \%\ O_2$$

As an example of the use of these formulas, take the illuminating gas tabulated above, and assume 50 per cent. excess of air, that is, $X = 1.5$.

$$c = 15 + 25 + 2 \times 3 + 6 \times 2 + 4 = 62$$

$$A = 0.5 \times (15 + 45) + 2 \times 25 + 3 \times 3 + 7.5 \times 2 - 1 = 103$$

$$T = 62 + (4.75 \times 1.5 - 1) \times 103 + 5 = 698$$

from which the products of combustion are

$$\textit{Per cent. } CO_2 = \frac{62}{698} \times 100 = 8.9$$

$$\textit{Per cent. } O_2 = \frac{(1.5 - 1) \times 103}{698} \times 100 = 7.4$$

$$\textit{Per cent. } N_2 = 100 - 8.9 - 7.4 = 83.7$$

Using the curves for a fuel in actual use, the amount of air consumed may readily be obtained from them if the percentage of CO_2 is found by exhaust-gas analysis. This is done by finding the value of the excess coefficient corresponding to the percentage of CO_2 from the curve, and multiplying the excess coefficient so found by the amount of air theoretically required for the complete combustion of 1 lb. or 1 cu.ft. of the fuel. This last quantity may be found from the following formulas, using the same notation as before.

For oils and coal, the pounds of air required per pound of fuel = 0.116 C + 0.348 H.

For gases, the cubic feet of air required per cubic foot of fuel $= \frac{A}{21}$.

When oil is burned under furnaces with air under pressure, very little excess air is needed for complete combustion. In internal-combustion engines, however, it is generally better practice to use dilute mixtures yielding low percentages of CO_2.

A Steam-Gas Power System

H. Ray, assisted by C. J. Smith, both of Toledo, gave an illustrated lecture on the above subject before Illinois Association No. 1, Chicago, of the National Association of Stationary Engineers on Oct. 15. The apparatus described consists of a boiler and engine, of special design.

The boiler is cylindrical in external form, upright in position and contains three sets of horizontal tubes or conduits. The tubes of any set are connected with each other in series by vertical lengths of the same diameter. The sets are arranged in vertical rows, the main set, communicating with the furnace, being in the middle.

The fuel employed is crude oil or any of its distillates. The furnace is located in the upper part of the shell with its top just below the water line in the boiler. The gases of combustion pass upward through a few horizontal lengths of fire tubes surrounded by steam, thence downward through the balance of the tubes, surrounded by water and out to the atmosphere at the bottom. Forced draft is employed in supplying air to the furnaces. In starting up with a cold boiler the gases of combustion are short-circuited through a conduit to a stack above the water. A conduit or retort, in the furnace, through which the oil is first passed, serves to vaporize and preheat the fuel before it is fed to the furnace.

The superheated steam yielded by the boiler is utilized in the crank end of a combination steam-gas engine. In the head end some of the oil volatilized in the furnace retort is used in the same way as in a four-stroke-cycle gas engine. The head end of the cylinder is jacketed and the water circulated therein is drawn from the lower portion of the boiler where the temperature is the lowest and discharged back to the boiler at a point where the temperature in the boiler corresponds with the temperature of the jacket discharge.

The exhaust from the gas end of the cylinder is passed through two sets of tubes which commence at the very top of the boiler and extend to the bottom in horizontal layers, passing first through the steam space and then through the water space. It is claimed that thus the gases first supply heat for superheating the steam and later help to heat the cool water below. The exhaust from the steam end of the cylinder is discharged into the same set of tubes as the exhaust gas and commingle therewith. The exhaust steam, however, instead of being admitted at the top of the tubes, is admitted at a point lower down where the temperature of the water surrounding the tubes is about 212 deg. The mingled exhaust gas and steam are discharged into a tank below the boiler and the steam, now condensed, is recovered for boiler-feed purposes while the gases escape through a vent.

The lecturers stated that a 100-hp. experimental unit showed a thermal efficiency of 60 per cent. No units have been built as yet for commercial use.

✿

Two new fuel ships, the "Kanawha" and the "Maumee," are now under construction for the United States Navy. The former will have two, three-cylinder triple-expansion engines of 2600 hp. each and is being constructed at a private yard. The latter, however, will be propelled by two Nürnberg Diesel engines of approximately the same power as the steam engines in the sister ship. Although the hull of the Maumee will be constructed at the Mare Island Navy Yard the engines will be built at the Brooklyn Navy Yard from plans purchased abroad, and will be shipped to the Pacific coast.

These two ships will afford an excellent opportunity for determining the relative merits of oil and steam engines under like conditions.

REFRIGERATION DEPARTMENT

Thermal-Testing Plant of Pennsylvania State College*

By J. A. Moyer†

Less than a year ago the Pennsylvania State College established and equipped the largest and most elaborate thermal-testing plant in America, and during the short time the plant has been operating some interesting results have been obtained.

Every effort has been made to eliminate the difficulties usually encountered in testing materials to determine the rate of heat transmission. The calorimeter is roomy, so that large samples can be tested. The means are also available for measuring and varying the velocity of the air, and by means of accurate and delicate platinum resistance thermometers located in the calorimeter room, at the inside and outside walls of the material being tested, as well as on the surface and imbedded at various distances in the body of the material, it is believed very accurate determinations can be made.

The plant consists of two separate brick buildings. One building is 50x18 ft. and is used to house a complete 10-ton experimental refrigerating plant; the other building, which is the testing plant proper, is 32x32 ft. on the outside, and contains the calorimeter room which is 17x17 ft. This room is cooled to low temperatures by a number of rows of brine coils encircling the room. Cold brine is supplied from the refrigerating plant in the adjacent building through 2-in. heavily insulated pipes. Each of the materials to be tested is made up into a cubical box of approximately 150 sq.ft. of outside surface; and this box is then suspended in the calorimeter room for testing. An electric fan and an electric-heating coil are placed inside the box for producing the required uniformly distributed temperature difference between the inside and the outside of the box.

By this method tests can be made for a great range of temperature differences. Absolutely constant and uniform temperatures can be maintained for an indefinite period of time, and the heat put into the box per unit of time is measured by accurately calibrated voltmeters and ammeters on both the coil and the fan circuits. Direct current is used. Twenty platinum resistance thermometers are available for measuring the temperatures, inside and outside the testbox as well as in its walls. Cylindrical platinum coils are used for measuring the temperatures in all places except on the surfaces of the material, where thin platinum resistance disks less than 0.02 in. thick are firmly attached to the surface on their flat sides. Adopting the method of the U. S. Bureau of Standards the temperatures have been observed in each test in the following locations: (1) 2 ft. from the surface of the material tested, inside and outside; (2) 1 in. from the surface, inside and outside; (3) on the inside and outside surfaces by absolutely close contact; (4) at every inch of thickness through the material, also with thin flat platinum resistances which can be accurately located.

Air velocities outside the testbox were varied by the use of six variable-speed ventilating fans. Some of the most important data obtained during the last year are presented briefly in the following:

Table 1, giving the results of tests of a cork-board cube, shows the effect on the heat transmission of varying the air velocity over the outside of the surface of the box.

TABLE 1. VARIATION OF HEAT TRANSMISSION WITH AIR VELOCITY

Air Velocity Ft. per Min.	B.t.u. per Sq.Ft. per Deg. F. Diff. per Hr.
222	0.130
298	0.133
437	0.137
800	0.159
898	0.169
900	0.170
905	0.170

These data show that the transmission is increased about 34 per cent. as the velocity of the air is varied from 222 ft. per min. to 905 ft. per min., or the transmission is changed 5 per cent. per 100 ft. per min. change in velocity. In all these tests the velocity of the air inside the box was approximately 200 ft. per min. Velocities were measured with a carefully calibrated anemometer.

Tests made to show the change of transmission with variation in humidity showed the results given in Table 2.

TABLE 2. VARIATION OF HEAT TRANSMISSION WITH HUMIDITY

Relative Humidity Per Cent	B.t.u. per Sq.Ft. per Deg. F. Diff. per Hr.
70	0.170
76	0.171
84	0.173
90	0.174

By increasing the humidity from 70 to 90 per cent. the transmission is increased 2.4 per cent., which is equivalent to a change of 1.2 per cent. in transmission for a variation of 10 per cent. in humidity. Velocity of the air outside the box was 900 ft. per min.

The most remarkable effect of velocity on heat transmission is shown by the data in Table 3, for the temperature drop in passing from the interior of the cork-board box to the outside. The cork-board was 3 in. thick. The data represents the average of six consistent tests, some of which were continued for 20 hr. The velocity of the air inside the box was 200 ft. per min. and that outside was 950 ft. per min. in one case and practically zero in the other.

The effect of air velocity on the temperature gradient within the cork-board walls is remarkable, and every precaution has consequently been taken to check the results. About 25 different tests have been made on the cork-board and also on cubes of other building materials, and the same general effect has been observed. In the case of a single thickness of glass, the temperatures on the inside and outside surfaces are practically the same for a total temperature difference of 55 deg. F., showing that the glass itself has practically no heat-insulating properties. With practically "still air" outside the glass box and with this total range, there is a difference of 28 deg. between the temperature of the surface and the temperature

*Abstract of paper read before the Third International Congress of Refrigeration.

†Professor in charge of Pennsylvania Experiment Station.

TABLE 3. VARIATION OF HEAT TRANSMISSION THROUGH 3-IN. CORK-BOARD

Locations of Thermometers	Air Velocity 600 Ft. per Min. Reading of Ther.	Temp. Diff.	Practically Still Air Reading of Ther.	Temp. Diff.
1. Air inside box*	117.5		117.8	
2. Air 1 in. from inside surface	116.5	1.0	117.0	0.8
3. Inside surface of cork-board	113.5	3.0	114.0	3.0
4. Temperature in cork-board 1 in. from inside surface	86.5	27.0	94.0	20.0
5. Temperature of cork-board 1 in. from outside surface	57.0	29.5	66.5	27.5
6. Outside surface of cork-board	48.0	9.0	51.5	15.0
7. Air 1 in. from outside surface	47.5	0.5	47.5	4.0
8. Air outside box*	46.5	1.0	46.5	1.0

* Thermometer located 2 ft. from cork-board wall.

registered by a thermometer located at a distance of 1 in. from the surface. On the other hand, with a velocity of 600 ft. per min., this difference is 10 deg.; and with a velocity of 950 ft. per min., the difference is only 7 deg. In view of this great variation between the temperature at the surface and the temperature registered by a thermometer located close to the surface, it seems to be necessary that a definite standard location be adopted for measuring the temperature difference in heat-transmission tests and calculations. Since only specially designed and expensive thermometers are adaptable for measuring surface temperatures, the location recommended by the U. S. Bureau of Standards; that is, at 1 in. from the surface, should be generally acceptable.

Table 4 gives a number of values of heat transmission as determined in the plant described. The temperatures were observed at 1 in. from the inside and outside walls, and the velocities were in all cases about 200 ft. per min. Humidity was about 80 per cent.

TABLE 4. UNIT HEAT TRANSMISSION FOR VARIOUS MATERIALS

B.t.u. transmission per sq.ft. per hr. per deg. F., difference in temperature of air	
1-in. common brick	4.66
One 4-in. hollow tile	0.625
1-in. concrete (1-3-5 mix.)	4.29
¾ in. lumber (t and g)	0.83
One air space (from 1 in. to 6 in.)	1.66
1-in. mineral wool (dry)	0.666
1-in. building paper	0.30
1-in. pitch	0.79
1-in. shavings (dry)	0.666
1-in. granulated cork	0.479
1-in. hair felt	0.31
1-in. indurated fiber board	0.416
1-in. compressed mineral wood board	0.33
Single window (all glass)	1.09

❖

Present Status of the Refrigerating Industry in America*

By S. S. Van Der Vaart

In a glance at the present status of the refrigerating industry in America, one is struck by two points of salient interest to those engaged in industries utilizing artificial refrigeration. One is the gradual, and during the past few years, rapid extension of the ice-manufacturing industry northward into the domain heretofore thought to be the prerogative of natural ice, so that today great ice-manufacturing establishments are being erected in Portland, Maine; Boston, Mass.; and in Montreal, Toronto, Winnipeg, Calgary and other cities in Canada. In New York City, where in 1904 less than 20 per cent. of the total amount of ice consumed was manufactured ice, by 1913 the ice machines furnished practically 65 per cent., and when plants now under construction or planned for erection during the coming winter, are completed, the proportion will be nearer 75 per cent. manufactured to 25 per cent. natural ice. In cities like Dubuque and Sioux City, Iowa, and Minneapolis and St. Paul, Minn., where natural ice is abundant, easily obtained and cheap, ice-making plants have been or are being erected.

In regard to the opening of new fields for the use of refrigerating machinery, it is only necessary to point out the use of refrigerating machinery in the laundry to cool the starched collars and cuffs after leaving the mangle and before they are passed through the shaper. Another instance of new use for refrigerating machinery is found in the mining and metallurgical industries. In the process of treating ores with chlorine gas on a large scale, the recovery and condensation or liquefaction of the chlorine becomes essential. The liquefaction of chlorine gas at atmospheric pressure takes place at —29 deg. F., and the recent installation of a refrigerating plant capable of liquefying 850 lb. of chlorine gas per hour is reported from a Western mining field. Again, it was found that with the aid of refrigeration it is possible to extract gasoline from natural gas. In the paper-making industry refrigerating apparatus is being used to some extent to control temperatures during the treatment of the pulp and in such operations as the manufacture of wax paper from plain tissue paper.

The use of refrigerating machinery in testing delicate machinery, such as automobile parts, gasoline motors, or complete motor cars, has been tried recently with valuable results. A room is provided where temperatures of zero Fahrenheit or below can readily be maintained and here the performance of the machine is tested under the equivalent of winter conditions and with different grades and kinds of fuel in order to determine beforehand what particular combination produces the greatest efficiency.

An interesting extension of existing fields is in the preservation of the delicate ferns that grow in great abundance in the forests of Massachusetts, New Hampshire and Vermont and are in great demand in the Eastern cities for decorative purposes during the holiday season. In a New York zoölogical park, refrigeration is used to retard the opening of cocoons of rare and beautiful insects and moths, so that their short-lived beauty may be shown in the parks throughout the entire summer season.

Refrigeration is found to be advantageously applied in the preservation of seeds, such as apple and other fruit seeds, including also seed potatoes and grains. The fruit seeds are frozen and held at freezing temperatures, and seed potatoes and grains at temperatures just above the freezing point of water. The freezing of fresh, ripe berries and also cherries, and holding them in the frozen state until ready for use, is an application recently introduced and used by bakers and others.

Among other new applications of refrigeration is its use in the shipment of date-palm shoots or cuttings, also its use for curing or preventing tropical diseases and in some cases apparently curing the distressing affliction known as "hay fever."

In the field of invention, the development of the so called "flooded freezing system," or gravity feed of liquid refrigerant through the freezing coils in ice tanks, has reached quite general application. The removal of coils in the freezing tanks and the substitution of a brine cooler laid in one end of the tank through which all brine is circulated, is another recent development. The several systems of producing clear crystal ice from raw, or undistilled, water have reached practical development, and

* Abstract of paper read before the Third International Congress of Refrigeration, Chicago.

a number of raw-water ice-making plants are now in operation or being installed. Recent improvements in construction of ammonia condensers have resulted in considerably greater efficiency of this important portion of the refrigerating plant.

A brief survey of the development of the refrigerating industry in America will give some idea of its magnitude at the present time. It may be added that refrigeration is today still at its high-water mark of growth and extension. The latest available authentic statistics indicate that there are about 3500 ice-manufacturing establishments in the United States, equipped with machinery capable of producing between 18,000,000 and 20,000,000 tons of ice annually. The latest census reports gave the number of ice factories as 2004 in 1910, but this covers only those engaged primarily in ice making. There are many meat packers, brewers and others engaged primarily in other lines that also operate ice-making plants—some of these of very large capacity—which partly accounts for the wide discrepancy between the census report and the facts as they exist. The capital invested in the ice-making industry proper is estimated at not less than $150,000,000.

Cold storage includes so wide a field that it is difficult to estimate even the number of places where cold storage on a large or small scale is carried on, for at least 2000 meat markets have cold-storage rooms cooled with refrigerating machinery; about 1100 creameries, dairies and cheese factories are so equipped; about 350 ice-cream factories and about 350 produce dealers have cold-storage rooms equipped with refrigerating machinery. Again, in the fruit industry there are many hundreds of small cold-storage establishments scattered throughout the country, where fruit is held for short or long periods under refrigeration, and adding to all these between 800 and 900 commercial cold-storage warehouses, varying in capacity from 25,000 cu.ft. to 11,250,000 cu.ft. capacity, which is the capacity of the largest single cold-storage house in America, and some idea is gained of the vast extent of cold storage at its present state of development.

A list of the principal users of refrigerating machinery in the United States would include the following: 3500 ice-making plants, 1300 breweries, 600 packing houses and abattoirs, 2000 meat markets, 1100 creameries, dairies and cheese factories, 700 hotels, 1000 fruit-storage houses, 350 produce commission houses, 320 office and public buildings, 300 provision dealers, 300 liquor stores, 300 hospitals, 300 candy makers and confectioners, 250 restaurants, 250 schools and colleges, 200 groceries, 160 apartment houses and residences, 150 fish-freezing and storage houses, 150 oil and lard refineries, 100 carbonated beverage manufacturers, 100 bakeries, 100 club houses, 50 fur-storage establishments, 50 florists, 50 laboratories, 40 manufacturers of explosives, 30 army posts, 30 mineral-water bottlers, 20 bleachers and dyers, 20 glue factories, 18 photo-material manufacturers, 15 textile works, 15 soap factories, 13 electrical-instrument manufacturers, 10 sugar refineries and 5 manufacturers of ammonia.

Besides, numerous refrigerating installations are used in mercerizing works, silk and woolen mills, in the manufacture of perfumery, celluloid, isinglass, flavoring extracts, candles, glass, acetylene gas, vinegar, wine, snuff, tobacco, leather, cutlery, agricultural implements, optical instruments, temperature-measuring instruments, liquid air, etc.; for shaft sinking and tunneling; for recovery of alcohol and ethers; for prolonging animal hibernation; for retarding plant growth; for cooling air in hotels, restaurants, stores, factories and residences, and for numerous other uses.

The total number of refrigerating machines in actual use in the United States is estimated at about 20,000. The capital invested in construction of machinery for refrigeration is estimated at at least $50,000,000. The capital invested in industries depending wholly or largely upon the aid of the refrigerating machine is estimated at more than $1,000,000,000.

❖

Direction of Flow in Brine Cooler

At the plant that I have charge of there are two exhaust-steam machines of the absorption type for cooling cold-storage rooms. They are of 15- and 25-ton capacity respectively. I think the coolers are piped wrong and would like to hear what some of the readers think about it. We use calcium brine, and both brine and ammonia

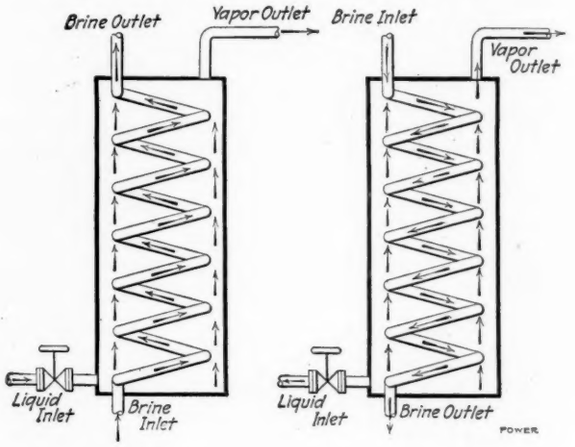


FIG. 1

FIG. 2

enter the bottom of the cooler and leave at the top. This is shown in Fig. 1. I would naturally think that the warm brine ought to enter the top where the ammonia is warm and leave at the bottom where the ammonia is the coolest, as shown in Fig. 2.

We have a great deal of trouble in making the cooler boil off enough gas to get the capacity of the machine. I think if the current of brine were changed so that it would flow in a direction opposite from the ammonia, it would give the cooler a greater capacity.

Another point that I wish to inquire about is this: We have only one circulation of brine for cooling the warehouse. We have two brine pumps, but they both pump to either cooler. Would it be better if they were piped to the separate coolers so that one pump could be used on one machine and the other pump for the other machine? When both machines are running we have a great deal of trouble dividing the work properly between them, because the brine going to each cooler cannot be divided properly.

H. E. HOOPER.

Pittsfield, Mass.

EDITORIALS

Power-Plant Depreciation

A power plant uses up engines as well as coal and oil. If an engine costs twenty-thousand dollars and lasts twenty years, the plant has used up, on an average, one thousand dollars worth of engines a year, and this must be taken into account in making up the cost of power just as certainly as the cost of the coal, labor, repairs, etc., for which money is actually paid out each year.

It is usual to charge the plant with a certain percentage of "depreciation," diminution of value used-up-itiveness each year. A common figure is five per cent., which assumes that the plant would need to be entirely renewed in twenty years.

Charles M. Ripley has collected some data bearing upon the life of plants in and about New York. He furnishes a list of plants of which one has been running thirty years; two, twenty-nine years; two, twenty-five years; two, twenty-three years; five, twenty-two years; two, twenty-one years; one, twenty years; six, nineteen years, etc. An increasing number can naturally be found for the shorter ages. Most of the plants enumerated were put in by Pattison Brothers, a firm of consulting engineers, with which Mr. Ripley is identified.

The significant point is that these plants, even the oldest of them, are running along nicely, and there seems to be no good reason why any or all of them may not be in active and efficient service after a number of more years of use.

Any attempt to boost depreciation above five per cent. in an effort to show high cost of production is not justified for a plant which will have ordinarily good care.

❖

The Smoke Evil

Experts figure that Pittsburgh's yearly soot emissions would make a pile one hundred feet in diameter and six hundred feet high or larger than the Washington monument. The money waste and damage are estimated at twelve million dollars yearly. Sample tests made some time ago in Chicago of the cost of the smoke nuisance in that city showed that the smudge bill exceeded the tax bill which was about forty million dollars a year, and the cost of smoke in other cities is fully as great in proportion to the size of the city. This includes only the injury to property. Doctors will tell you that is the least damage. They will point out how the smoke gets into the throat and lungs, and injures the health, causing chronic ailments which diminish the happiness and shorten the life of those who are not responsible for the smoke evil.

The old saying is, "Much smoke much business"—and we need the business. But the progressive engineer of today will tell you that most smoke can be avoided. It indicates incomplete combustion which means waste of coal, extra expense in labor and equipment, damage to property, sickness and loss of life. Experts say business can be done as well without smoke and point out some of the uptodate plants and cities as proof that it is unnecessary to make smoke.

In many cases it is cheaper to let the boilers smoke than it is to take measures to prevent it. Then comes the question: How can it be done, and what will it cost? There are many ways to abate smoke not all of which will work in every case, but some of them at least can be made to work in every plant. And in many cases the saving in the amount of coal consumed will pay for the installation of a good system.

Using anthracite and semi-anthracite coals will reduce the amount of smoke made as they contain a lower percentage of volatile matter, but the cost per million heat units and the trouble in getting them are too great in many localities. Bituminous coal contains a higher percentage of volatile matter but as a rule costs less per million heat units and is most universally used.

The first requirement of a smokeless boiler plant is to have the boilers properly set. Ample space must be given in the furnace for complete combustion to take place before the flames come in contact with the comparatively cold boiler. The boiler must be set higher from the grates than formerly, but that requirement alone is not sufficient. When firing by hand the fireman is apt to throw in so much coal at a time that the proper amount of air cannot reach the hydrocarbons that are being driven off when the coal is first thrown in to form complete combustion and the result is smoke. Firing in small quantities alternately, first one side and then the other, will help, and provision should be made to admit air over the fire while the hydrocarbons are being driven off. Coking the coal on a coking plate in the front end and then pushing it back over the grates will prevent smoke but makes so much extra work that it is not always feasible. The dutch-oven furnace with the long combustion arch has proved successful in many cases when properly handled.

There are many so called "smoke consumers" on the market which, when applied to boilers, automatically admit a certain amount of air into the furnace over the fire while the hydrocarbons are being driven off. This usually prevents smoke but sometimes at the expense of the coal pile, as they are not always economical.

Mechanical stokers will prevent smoke and give more complete combustion if properly installed and operated. Of these there are two general types. The overfeed and the underfeed. The overfeed uses the coking arch principle, and the coal as it is slowly fed in at the front or side gradually gives off its volatile matter which is ignited as it passes over the incandescent carbon at the rear of the furnace, and is completely burned. In the underfeed type the fire is above the green coal and the air enters at the bottom where it mixes with the hydrocarbons and must pass directly through the incandescent carbon to get into the combustion chamber; consequently combustion is more nearly complete.

But with all of these improved furnaces the human element must be taken into consideration for their successful operation. The day has come when the fireman must be something more than a laborer. The most perfect smoke consumer or furnace ever made will not work satisfactory if it is not properly handled.

The fireman must understand the theory of combustion, he must know how to control the admixture of air and coal, he must know how to analyze the flue gas and how to interpet this information, and, when put in charge of a properly installed boiler plant, must understand machinery, as well as know how to meet the demands of the boilers for steam. Last but not least he must be given some incentive to operate the plant in the most economical manner, and the greatest of these inducements are good wages and respectable treatment from the employer. A good installation plus a satisfied operator means a smokeless stack and a small coal bill.

In some localities the law requires boiler plants to be operated without making smoke and these laws are being complied with to a greater or less degree. If it can be done in one place there is no reason why it cannot in any other, if the conditions are made right. It is the duty of the lawmakers to make these laws and enforce them to prevent poisoning the air and for the benefit of humanity, and, it is the duty of the plant owner to obey them by properly installing the boilers and furnaces, and compelling those in charge to properly operate them, not only because the law says so, but to receive the benefits of the heat units that are going to waste up the stack through carelessness and neglect.

We boast of big cities. Why not clean cities as well?

Power-Plant Foresight

If a power plant is ever in condition to operate efficiently it would seem it should be just after it has been completed. Then everything is new and in perfect condition. But, perhaps, after running smoothly for several years, the efficiency begins to drop. What is the reason?

Experience has shown that it is sometimes necessary to make extensive alterations in a newly constructed power plant, because of faulty design. If the chief engineer of such a plant does not recognize the necessity of remedying the defects when discovered, the plant stands to run at low efficiency.

If a new chief engineer assumes charge and discovers the necessity of alterations; the expense of making them is entered against his administration. The first year's expenses will be excessive, but later developments will probably show that the economy of the plant is greater than it ever could have been with the original layout.

Engineers are as likely to err in judgment as others. It is as disastrous not to make desirable alterations as it is to make changes which are not instrumental in producing better plant economy.

An engineer requires what might be called a sixth sense, besides the acknowledged five senses. This extra sense enables him to look into the future, and see what is going to be required in the line of future equipment. Such an engineer will be capable of designing a power plant that will not have to be remodeled a few months after it has been put into use.

To illustrate: A small Western city voted to build and operate its own electric-light plant, and a very conservative figure as a probable cost was given. No forethought was used as to the probable growth of the electrical load, and the capacity of the original installation was but slightly in excess of the initial demand. Consequently, in a few months, the equipment was overloaded and plans had to be made for enlarging the plant. Another boiler was installed, the original engine was discarded, instead of being set up as a spare unit, a larger engine put in and additional generators purchased.

Here, then, was a new plant practically rebuilt shortly after it had originally been put into service, because someone had not the foresight to anticipate the probable increase in load demand.

As a contrast, an engineer was confronted with the problem of keeping the machinery of a plant in operation while the walls and roof of a new building were being reconstructed, the old building having burned down.

Notwithstanding the worry and anxiety of operating the machinery, there was the necessity of planning the interior of the plant, so that when future installations were put in the equipment would be arranged symmetrically, and of sufficient capacity to take care of the load for years to come, by which time the apparatus would have become obsolete and inefficient.

These are typical of two kinds of engineers, the one responsible for efficient and the other wasteful power-plant operation. In one the faculty for looking ahead was highly developed, in the other such vision was totally lacking. There are many of the latter, and all too few of the former type of engineers.

Informality in Public Service Laws

"Simplicity is one of the strong features of the law. It will not require a specialist to construe the statute." In these words, James L. Clark, a member of the Indiana Public Service Commission, recently sought to make plain that commission's laws and its working plan before the Indianapolis Lawyers Club.

To many who have followed the procedure of public-service commissions, the simplicity of their laws has been an unknown quantity. As to the necessity for specialists, it would seem that their assistance was indispensable if the petitioner hoped to gain further privilege or perhaps, in a few instances, evade his responsibilities.

It has been decided, declares Mr. Clark, that the Indiana commission's proceedings shall be conducted without the usual formality of the law; in fact, that the "very purpose intended to be accomplished by the Indiana law requires the practice to be entirely void of technicalities."

There is too much unnecessary delay in the work of some of the service commissions, due in a great measure, to the extremely formal and technical composition of public utility laws. Because of this, counsel are able to quibble or acrimoniously discuss their cases to the disadvantage of public service and make justice expensive at the hands of technical "experts."

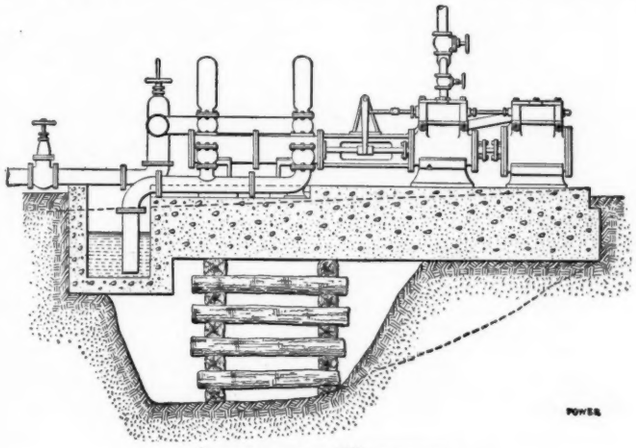
Laws must be so framed as to properly protect and develop the welfare of the state, but it is possible to accomplish the purpose of the service commission's existence and still have the law fairly free from technicalities and simple and informal in its interpretation. The work of the Indiana commission will be watched with a great deal of interest.

READERS WITH SOMETHING TO SAY

Washout under Pump Foundation

At a steel plant where two duplex compound-pressure pumps were installed the connections in the discharge line broke. The line was under 650-lb. pressure and the water washed away the soil underneath the foundation with the result that the pump settled over a foot at the water end, as indicated by the dotted line.

A gang of laborers was put to work to excavate and remove all loose soil under the foundation, and in less than a week the pump was resting on a pier of ties, the foundation and pump leveled and jacked up, and running as usual. The men had to dig down 25 ft. to reach



AFTER THE WASHOUT

solid rock. After the ties and later two concrete piers to support the foundation were in place, and while the pump was running the ties were removed and the space filled in with concrete.

EDWIN C. MILLER

Lakewood, Ohio.

Fitting Crankpin under Difficulties

Some years ago I took charge of a large sawmill plant in the isolated Algoma district of Canada. Soon after the plant was started the main engine developed a startling pound. Investigation showed it to be in the crankpin, which, I discovered, projected through the crank disk and had a small pin inserted through it at right angles to the axis of the pin. I drove out this small pin and hit the crankpin a slight blow with an ordinary hammer, whereupon it fell out on the floor.

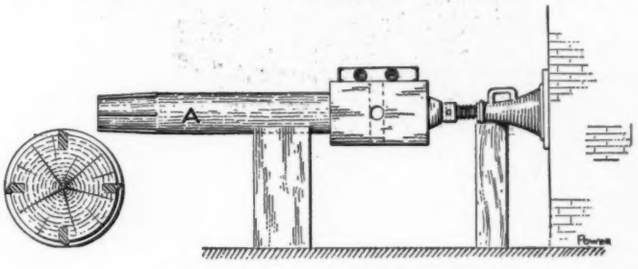
Here I was, 200 miles from the nearest machine shop and undoubtedly as far from a machine lathe. The main engine was crippled and it was the busiest part of the cutting season.

I put a liner of thin sheet iron around the pin and drove it in place. Two days later the weekly mail boat arrived and I sent a hurry order to a machine shop for a new pin, stating that we were running with a loose crankpin. Realizing that the loose pin would wear the pin bore much larger, I ordered the new pin large enough to fit the increased size of the bore.

Two weeks elapsed before the new pin arrived and with it came a letter from the shippers stating that they knew the pin bore would wear larger on account of the loose pin and they had made the new pin larger than the measurements specified to allow for the wear of the bore.

Imagine the situation! The new pin would not go more than half way into the bore and filing it down was out of the question. I dared not risk waiting another two weeks for fear the disk would break.

Beyond the woods in the village was a little planing mill which I knew had a wood-turning lathe. On this



AN IMPROVISED BORING BAR

lathe I turned an oak spindle *A* with a taper the same as the taper of the pin. Cutting tools shown in the enlarged end section of *A* were made out of files and wedged securely in the spindle. A screw-jack and a block with holes for handles were used to turn and feed the spindle while enlarging the bore in the crank disk. The boring bar was kept in line with the disk by keeping it true with a try-square. On Saturday night we bored out the hole and by Sunday noon after heating the disk we drove in the pin and fastened the connecting-rod.

Many years after this experience I saw this engine and the same pin was still giving service.

E. E. THOMPSON.

Thessalon, Ont.

Removal of Scale by Graphite

Much has been said recently on this subject in several engineering periodicals and the writer desires to give some notes of his recent experience with graphite as a scale remover.

We have four Stirling boilers of 300 hp. each, three under pressure at all times, the other being down for cleaning or repairs. Our boilers are frequently overloaded for short periods. We use natural gas for a fuel with Kirkwood burners set in a vertical position, eight on each side of the ashpit, using an average pressure (at the burners) of 3 oz. The working steam pressure is 150 lb. gage.

The water used in the boilers is taken from the city mains and passes through an open heater where the temperature is raised to 208 deg. F. At the city pumping

station the water is taken from the river and pumped to settling tanks from which it flows by gravity through modern sand-filtering apparatus, thence through the pumps to the reservoir and lines, and during the process

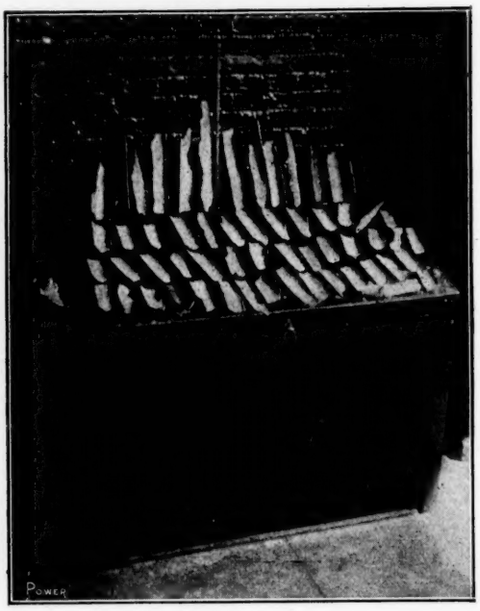


FIG. 1. BOILER SCALE REMOVED WITH GRAPHITE; NOTE TWO-FOOT RULE IN CENTER

of filtering a sufficient amount of alum solution is added for purifying purposes.

We have had analyses made of the feed water and of the scale and tried out several boiler compounds without satisfactory results. We then tried kerosene by placing a quantity in each drum after cleaning, but the results were poor.

Tri-sodium phosphate was then tried and this did not help the scale problem, but gave the scale and the interior of the boilers a very red or rusty appearance, where-

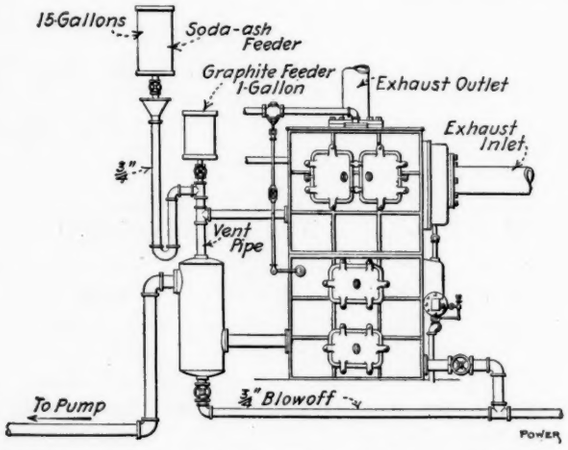


FIG. 2. SODA-ASH AND GRAPHITE FEEDER CONNECTED TO FEED-WATER HEATER

upon the insurance inspectors reported corrosion. A small amount of soda ash is fed in with the feed water daily to neutralize the acid in the water, much of the acid coming from coal and coke works farther up the stream. Precaution must be taken here as too much soda ash will cause the boilers to foam. With boiler graphite we are getting good results at a very small cost, using only one pound per 24 hr. During this process we also tried out several mechanical cleaners as we do not believe this type of boiler can be kept clean without a good mechanical cleaner to knock out the scale after the chemicals and graphite have done their work.

In Fig. 1, compare the size of the scale to the 2-ft. rule in the center. One piece of scale was over 17 in. in length, but became broken in handling. Most of the scale is very thin; so much so that the boilers would ordinarily have been considered clean. Most of the scale was loosened and fell before the mechanical cleaner reached it, as that reached by the cleaner is pounded fine or will have marks of the cleaner on its surface. A well known make of water-turbine cleaner is used, and never before in the writer's nine years' experience in this plant did the scale come down so easily or in such large pieces as it has since using boiler graphite.

Fig. 2 shows our method of feeding the soda ash and graphite solutions to the feed water as it leaves the heater on its way to the pumps. In this way the graphite adds its lubricating qualities to the pumps.

C. E. NIGH.

Morgantown, W. Va.

The Myriawatt

As one of the authors of the original paper, "The Myriawatt," presented before the convention of the American Institute of Electrical Engineers, June, 1912, I am sending an answer with tables to Mr. Weaver's criticism of the myriawatt in POWER, Sept. 9, 1913.

Mr. Weaver shows he is unaware of the purpose of the myriawatt and that he does not exactly understand just what it is. The purpose was defined in the original paper: "To introduce a new unit of power, which if adopted will afford a basis of comparison of all converters of energy, thermal and mechanical, and also will be international in its character, as it is merely a new multiple of the watt."

Mr. Weaver states that the unit has no scientific basis. Does he mean that the watt and the kilowatt have no scientific basis? If they have, why has not the myriawatt also, which is merely a decimal multiple of the watt, which means 10,000 watts? Even the boiler horsepower, confusing as it is, as now defined in the A. S. M. E. code for boiler tests, rests upon an entirely scientific basis. Mr. Weaver even finds fault with the use of "myria":

> While it is true that the word from which it is derived, means in Greek ten thousand, in English it has never had that definite meaning, but, as everyone knows, has the indefinite significance of a great number.

The following appears on page 1084 of Webster's Imperial Dictionary:

> Myriad (Gr. Myrias (ados), the number ten thousand, from myrios, countless).
>
> 1. The number of ten thousand, an aggregate of ten thousand persons or things.

While great confusion may result from the term "boiler horsepower," still it is well ingrained in American practice and about every American engineer has been accustomed to its use. The fact, as Mr. Weaver says, that the myriawatt is only 2 per cent. different in value from the

boiler horsepower, and still is based upon the same system of units as the kilowatt, recognized as the unit of engine-room output, is the main argument for the use of the myriawatt. It has all the advantages of the C. G. S. system, but still requires no effort to understand its value on the part of the engineer who has long been familiar with the boiler horsepower.

Mr. Weaver is under the impression that we intended there should be a "boiler rating based upon an engine heat consumption." He is mistaken, for we recognize that the tremendous increase during the last few years in efficiency of design and operation of boiler furnaces and prime movers has demonstrated that there can be no fixed quantitative relationship between the heat output of a boiler of a given size and the heat consumption per kilowatt of an engine. But thermodynamics teaches us that heat and mechanical energy are mutually convertible, and that a kilowatt-hour can be stated in terms of B.t.u., when the gravitational constant g is defined in value. The function of the myriawatt is to supply a power unit for the input side of a prime mover which is based upon the same system as the recognized unit of prime-mover output.

While it is true that the nominal rating of a boiler might be stated in myriawatts just as it is now occasionally expressed in boiler horsepower; nevertheless, the term myriawatt as an exact quantity means the power of ten thousands watts, or 34,150 B.t.u. per hour, based on the definition of g by Marks and Davis

$$g = 32.174 \text{ ft.} = 9.0665 \text{ meters}$$

To Mr. Weaver's statement:

> Again a boiler of 100 myriawatts actual on a basis of natural draft and anthracite coal for fuel would say, increase to 125 myriawatts actual with good soft coal, to 150 myriawatts actual with high chimney draft and to 200, 300 or more myriawatts actual.

I quote from the original paper: "With modern plants, notably those in marine service, operating at from two to five times this rating" (10 sq.ft. boiler surface = 1 boiler horsepower). We recognize that there is at present only a remote relationship between the actual output of a boiler and the nominal rating based upon heating surface. Even with stationary boilers, 400 per cent. nominal rating has been obtained. One speaks of a certain turbine as a 10,000-kw. machine and yet its output is almost never exactly 10,000 kw. Thus the actual output of a boiler may or may not correspond to its nominal rating. It may be as well to standardize once and for all the trade rating of boilers on the basis of square feet of heating surface, but that is entirely aside from the question of stating the thermal performance of a boiler in terms of a multiple of the recognized unit of prime-mover output.

Mr. Weaver, in a long letter to the *Electrical World*, completely riddled the boiler horsepower; but he left no adequate substitute. Let him search the universe for a better one which will be more simple and more clear of meaning than the myriawatt.

CONVERSION TABLES FOR THE MYRIAWATT

1 foot-pound	= 0.0012861 B.t.u.
1 kilogram-meter	= 0.009302 B.t.u.
1 gram-calorie	= 0.0039683 B.t.u.
1 horsepower	= 2,547 B.t.u. per hr.
1 cheval a vapeur	= 2,512 B.t.u. per hr.
1 pferde-kraft	= 2,512 B.t.u. per hr.
1 poncelet	= 3,349 B.t.u. per hr.
1 kilowatt	= 3,415 B.t.u. per hr.
1 boiler-horsepower	= 33,479 B.t.u. per hr.
1 myriawatt	= 34,150 B.t.u. per hr.

REDUCTION OF THE MYRIAWATT TO THE ABOVE UNITS

1 mw. = 34,150 B.t.u. per hr.
1 mw. = 8,605,000 gram-calories per hr.
1 mw. = 26,552,000 foot-pounds per hr.
1 mw. = 3,670,900 kilogram-meters per hr.
1 mw. = 13.410 horsepower
1 mw. = 13.597 cheval a vapeur
1 mw. = 13.597 pferde-kraft
1 mw. = 10.197 poncelets
1 mw. = 10 kilowatts
1 mw. = 1.020 boiler-horsepower

REDUCTION OF THE ABOVE UNITS TO MYRIAWATTS OR MYRIAWATT-HR.

1 B.t.u.	$= 2.928 \times 10^{-5}$ mw.-hr.
1 gram-calorie	$= 1.1621 \times 10^{-7}$ mw.-hr.
1 foot-pound	$= 3.7662 \times 10^{-8}$ mw.-hr.
1 kilogram-meter	$= 2.7238 \times 10^{-7}$ mw.-hr.
1 horsepower	$= 7.457 \times 10^{-2}$ mw.-hr.
1 cheval a vapeur	$= 7.354 \times 10^{-2}$ mw.-hr.
1 pferde-kraft	$= 7.354 \times 10^{-2}$ mw.-hr.
1 poncelet	$= 9.807 \times 10^{-2}$ mw.-hr.
1 kilowatt	$= 1.00000 \times 10^{-1}$ mw.-hr.
1 boiler-horsepower	$= 9.804 \times 10^{-1}$ mw.-hr.

The value of g is assumed to be that at sea level and 45 degree latitude = 9.80665 meters = 32.174 ft.

REDUCTION OF THE ABOVE UNITS TO GRAM-CALORIES

1 B.t.u.	$= 2.5200 \times 10^{2}$ gr. calories
1 foot-pound	$= 0.3241$ gr. calories
1 kilogram-meter	$= 2.3442$ gr. calories
1 kilogram-calorie	$= 100.0000$ gr. calories
1 horsepower	$= 6.417 \times 10^{5}$ gr. calories per hr.
1 cheval a vapeur	$= 6.329 \times 10^{5}$ gr. calories per hr.
1 pferde-kraft	$= 6.329 \times 10^{5}$ gr. calories per hr.
1 kilowatt	$= 8.605 \times 10^{5}$ gr. calories per hr.
1 boiler-horsepower	$= 8.4367 \times 10^{6}$ gr. calories per hr.
1 myriawatt.....	$= 8.605 \times 10^{6}$ gr. calories per hr.

HAYLETT O'NEILL.

New York City.

Abandoning Boiler in Case of Fire

To abandon a boiler in the face of a fire requires previous consideration, just as much as any of the other problems which are continually confronting the engineer of today.

If the burning building is small and composed of light material, as is frequently found in the warm climates, there is a pretty good chance of the building burning down from over the boiler without the latter being wrecked. Under this condition I would advise speeding up the feed pump sufficient to keep the boiler full of water when the safety valve opens.

On the other hand, if the burning building is large, the intense heat will certainly cause the boiler to be ruptured, so the engineer's duty, obviously, is to protect lives and property, even to the loss of his own. The energy which produces such disastrous results when a boiler explodes is stored in the hot water in the boiler. It would seem that the best thing to do would be to open the blowoff cock, and shut down the feed pump, thereby relieving the boiler of as much of its energy as possible before the explosion occurs.

J. M. ROW.

Fort McDowell, Calif.

Increased Face of Flywheel

In a plant where I was employed recently they had a 12x12-in. engine running 300 r.p.m. The flywheel was 5 ft. in diameter and formerly had a 10-in. face, but upon installing a new belt-driven dynamo of larger size a 14-in. belt was necessary, so it was a case of get a new flywheel or make the old one wider. The following method was used. A hard maple rim, 2 in. wide and of the same thickness as the flywheel rim, was made for each side of the wheel. The rim was made up of eight segments. After drilling and tapping out holes in the rim of the flywheel, the wooden rims were fastened to the flywheel

with 5/8-in. capscrews. After being securely fastened a tool rest was fixed, the engine started and the wooden rim turned off flush with the flywheel rim. The engine has been running successfully and the rim is as good as the day it was put on.

P. E. Flock.

East St. Louis, Ill.

Condenser-Tube Corrosion

In view of the fact that the corrosion and length of life of condenser tubes have been attributed to a great variety of causes, the article in Power for Oct. 14, pp. 531-533, which describes results of experiments conducted by the New York Edison Co., is welcome and interesting. There is, perhaps, no other power-plant problem that is as baffling of solution as the real cause of the erratic action of condenser tubes in actual operation.

This erratic action is observed in nearly every location where surface condensers are used, but the problem of explaining the causes for the action and the expenses due to experimenting and for replacing tubes is greatest in the large central stations usually located on the water fronts or river banks of the cities they serve. Consequently, the circulating water supplied the condensers is high in impurities, owing to the sewage and acids which find their way into the river.

Sewage usually contains more or less ammonia which is destructive to copper and its alloys of which condenser tubes are made. Ammonia is so soluble in water and the ammonia of water used in the usual sewage systems so great, and the streams into which the sewage is discharged usually so large, that it would seem as though the ammonia would be of such low concentration as to be harmless as a corroding agent. In cities like New York, however, where the population is dense, the water at times is highly polluted, as when the velocity of flow of the incoming tide is equal to that of the stream and there is no perceptible current. It would be interesting and valuable to read a discussion on the subject of sewage and trade wastes in circulating water as they affect condenser tubes.

Attributing the cause of pitting of condenser tubes to improper mill treatment, drawing and annealing, is the most logical argument yet advanced. One is convinced of the truth of this conclusion when studies of the microstructure of the tubes are made and considered in conjunction with the behavior of the tubes in actual service.

For example, it will sometimes be observed that of a lot of tubes of the same composition put in service at one time, some will corrode away in a few months, while others last as long as four years.

A case is recalled where two newly tubed condensers (all tubes of identical composition) were put in service at the same time, both operating under similar conditions of load, water, etc. After about four months' run the head was taken off one shell and the upper bank of tubes found so badly corroded that they were renewed, while the lower banks were unaffected. This started investigation which resulted in conclusions that were soon abandoned because examination of the other condenser showed the reverse condition, i.e., the top tubes were sound while the lower ones were seriously affected.

That local galvanic action set up between the constituents of the alloy and not electrolytic action of stray outside currents, causes tube deterioration is undoubtedly true. As an example of how firmly the former theory was believed in, the writer recalls one plant where a motor-generator set was installed to send current through the condensers in an opposite direction to that of the stray currents. It was always a question whether the current from the generator was assisting or opposing the electrolytic action.

Much interest has been shown in a report by Doctor Bengough on the corrosion of condenser tubes to the Corrosion Committee of the Institute of Metals of Great Britain.

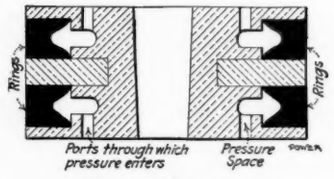
Doctor Bengough endeavored to show that pitting of tubes goes on more rapidly at high temperatures, say, 104 deg. F. and up, than at temperatures corresponding to high vacuum. Experience with the erratic action of tubes in condensers under 28 to 29.3 in. vacuum continuously during operation leads me to place little confidence in this theory. Discussion of this theory would, however, be appreciated.

B. H. Chester.

New York City.

Piston Rings Wear Cylinder

In reference to R. E. Skon's letter in the issue of Aug. 26 last, I have seen illustrations of devices to prevent the steam packing of pistons which is regarded as being undesirable, due to the excessive friction set up, causing rapid wear both of the piston and liner. I have a water piston fitted with flexible rings which rely on the pressure (160 lb. in our case) entering through four 1/8-in.



Section of Piston

ports to keep them tight against the cylinder walls and these rings wear rapidly. I have plugged up two of the ports, but it appears to make no difference and the quality of the rings is the best the makers supply. The pump is in good condition, being practically new. Can anyone offer suggestions to increase the life of these rings? A section of the piston is shown herewith.

A. M. Robb.

London, Eng.

Analysis of Mr. Chandler's Diagrams

The rise in the expansion curve was due to steam leaking into the cylinder from the receiver, due to the exhaust valve lifting off its seat when the pressure in the cylinder became less than that in the receiver.

The drop below the atmospheric line was due to a drop in the receiver pressure caused by the low-pressure cylinder drawing upon it while very little steam had been supplied to the receiver from the high-pressure cylinder during the previous stroke.

Frank P. Stoddart.

Burlington, Iowa.

[Similar replies were received from Harry D. Everett and E. H. Sawers.—Editor.]

INQUIRIES OF GENERAL INTEREST

Foot-Valve Action—Does a foot-valve on the suction pipe of a single-cylinder, double-acting water pump open and close while the pump is discharging water?

J. W. D.

At ordinary speeds of pumping and size of foot-valve, the valve on the suction pipe does not have sufficient time to close between strokes.

Plate Crushing Strength—What is meant by the "crushing strength" of a plate, in reference to figuring the bursting strength of a boiler?

J. W. D.

It refers to the resistance offered by the plate in resisting the compressive strain which exists on the edge of the plate behind a rivet, due to pulling the plate against the side of the rivet.

Injector Peculiarity—Why does high pressure sometimes cause an injector to refuse to lift water?

J. P.

Injectors for lifting water are made with a double system of tubing, viz., one for lifting and the other for forcing. The forcing system alone will do some lifting, but if too much steam is used, or enough used for forcing against high pressure, the suction becomes overheated and breaks by steam taking the place of the column of water to be lifted.

Power of Three-Phase Motor—On the "Inquiries" page of Oct. 14 issue, the statement appeared that the power of a three-phase motor is

$$\text{Kw.} = \frac{\text{Current} \times \text{voltage} \times 1.73 \times \text{power factor}}{1000}$$

This is correct for the input, but for the output it must be multiplied by the efficiency of the motor. The formula then becomes

$$\text{Kw.} = \frac{\text{Current} \times \text{voltage} \times 1.73 \times \text{power factor} \times \text{efficiency}}{1000}$$

Steam Consumption Corrected for Moisture—If the steam consumption of an engine is 28 lb. per i.hp., and the steam contains 2½ per cent. of moisture, how is the correction for consumption of dry steam made?

B. E. D.

If steam contains 2½ per cent. moisture, deduct 2½ per cent. from the actual consumption. For instance, if the actual consumption of the engine is 28 lb. of steam containing 2½ per cent. moisture, then the consumption of dry steam would be 28 — (2½ per cent. of 28) = 27.3 lb. This is the usual method of allowing for moisture in engine performances, although the presence of moisture is usually more detrimental to economy than thus accounted for.

Stack Height and Chimney Draft—Why is a boiler-furnace draft increased when the height of the stack is increased? What is the principle involved?

J. W. D.

The heated gases of a chimney rise because they have less weight or density than the atmosphere. The higher the column the greater its buoyancy or tendency to rise because the atmosphere pressing into the draft doors of the furnace is resisted by a column of less weight (gases and atmosphere) the higher the column of chimney gas extends up into the atmosphere. The effective pressure is that due to the difference between the weight of the heated gases in the chimney and a column of the external air of equal height and cross-section.

Engine Steam Consumption—Where a condenser cannot be used, how may the steam consumption of an engine be determined? Is it necessary in connection with this test to test the boiler for efficiency and weigh coal, water, etc.?

B. E. D.

The water consumption could be measured by weighing as it is fed into the boiler, if the latter supplied steam to only the engine, beginning and ending the test with the same steam pressure and same level of water in the boiler and accounting for any leaks or use of steam for other purposes. Steam consumption of engines is usually rated on a basis of dry saturated steam at some particular pressure. If only the engine economy is involved, then only the amount of water fed to the boiler and used by the engine would have to be taken into account; but if boiler efficiency is involved, the coal would have to be weighed.

Boiler Steaming Characteristics—Some claim a boiler steams better when the water is carried high; that if 2½ gages are carried less coal will be consumed than with 1½ gages. Is there any difference in coal consumption if the same amount of water is evaporated in both cases?

J. W. D.

A larger body of water carried in a return-tubular boiler may be accompanied by more uniform circulation and result in absorption of more heat of the furnace otherwise going to waste in chimney gases, thereby requiring combustion of more coal for a given evaporation.

For a given rate and system of firing, the larger the body of water the more uniform will be the pressure at which steam is generated, and for a variable rate of steam demand the larger the volume of water carried at a given temperature the larger the storage of heat and consequently the combustion can be regulated to the better advantage of the furnace economy than where the firing has to be adapted to the variable demands for steam.

Temperature Test Measurements—In a test, to take the temperature of the feed water before entering the weighing barrels, may an ordinary thermometer be used? Should the steam temperature at the throttle be obtained by steam gage or thermometer? Should the moisture in the steam at the throttle be obtained by fastening a calorimeter there?

B. E. D.

The feed-water temperature should be measured by a standard feed-water thermometer, which consists of a special thermometer dipped into a well in a brass screw plug, the well containing cylinder oil or mercury and the plug being screwed into the feed pipe so as to receive the full temperature of the feed water. The moisture is determined by a calorimeter attached where the quality of the steam is to be obtained. If the steam shows any moisture (which is probable unless a superheater is employed) there is no object in obtaining the temperature except from the pressure as shown by an accurate steam gage and tables of the properties of steam. Superheat thermometers are made and applied in the same manner as feed-water thermometers.

Latent Heat at Different Pressures—Why is there more latent heat in steam at 212 deg. F. than at 200 deg. i.e., why does the latent heat decrease as the pressure increases?

J. W. D.

A pound of water at 200 deg. F. passes into vapor by the addition of 977.8 heat units if the pressure is not in excess of 11.52 lb. per sq.in. abs. If the pressure is increased to 14.7 lb. abs., or atmospheric pressure, the water will not vaporize until its temperature has been raised to 212 deg. F. and in addition thereto, it has received 970.4 heat units. In the first instance the heat contained in the water above 32 deg. F. is 167.94 heat units and the additional heat required for vaporization being 977.8 heat units, the total above 32 deg. F. required for vaporization is

$$167.94 + 977.8 = 1145.74 \text{ B.t.u.}$$

commonly quoted as 1145.8 heat units. In the second instance the heat contained in the water above 32 deg. F. is 180 heat units; but with this amount of heat already present only 970.4 additional heat units are required for vaporization to make up the total of 1150.4. Why this is so cannot be stated. We only know from observation that temperature and pressure may be increased by addition of heat and that as temperature and pressure are thus increased the amount of latent heat required for vaporization decreases. It is a law of nature, the reason for which is inscrutable.

ENGINEERS' STUDY COURSE

Feed-Water Treatment—IV

Collecting Sample

Care must be exercised when collecting the sample to be analyzed. If the water is in an agitated condition a clean bottle or jar can be dipped into the tank or reservoir at almost any point and filled in the ordinary way. If it is more convenient to tap the supply main, a good arrangement is to allow a small stream of water to run into a clean barrel or tub continuously and dip the sample therefrom. The main thing is be sure that the bottle to contain the sample and the barrel or tub, if any is employed, are clean, and will not pollute the water with foreign matter which it does not contain naturally. A sample of from 2 qt. to 1 gal. is sufficient.

Test for Alkalinity

The first step of the analysis is to test whether the water is alkaline or acidulous in nature. Usually it is alkaline, but sometimes, when the water comes from boggy land, it may be slightly acid in character.

To test for alkalinity fill the 200-c.c. measuring flask, first seeing that it is thoroughly clean, with the test water, so that the level is exactly at the line which will be found around the neck of the flask. Empty this water into the clean 22-oz. basin and rinse the flask with distilled water, putting the rinsings into the basin also.

Distilled water may be purchased by the bottle, or if much is to be used, a home-made or purchased still may be found more economical.

Add to the 200 c.c. of test water in the basin two drops of the concentrated solution of methyl orange. Next, put into the burette some of the one-fifth normal standardized solution of hydrochloric acid and read the level at which the acid stands with great care and as accurately as possible. Now, titrate by opening the cock of the burette a small amount, allowing some of the acid to fall into the basin of test water drop by drop, stirring the water all the while with the glass rod, until the color of the water changes from canary yellow to orange and, finally, to faint pink. Shut off the acid at this point and again read the level in the burette as closely as possible. When reading the burette take as the level of the liquid the bottom of the slight curve which the surface of the liquid assumes due to the narrowness of the tube.

The analysis of a water sample is usually expressed in parts by weight of impurities per 100,000 parts of water. Thus, when a water is said to contain 20 parts of calcium carbonate what is really meant is that every 100,000 lb. of water contains 20 lb. of this compound.

Temporary Hardness

The test with hydrochloric acid as described above indicates the temporary hardness of the water and this is assumed to be caused by the presence of calcium carbonate in the water. To estimate the parts of calcium carbonate per 100,000 multiply the number of cubic centimeters of acid required by 5.

To illustrate, if it took 4.1 c.c. of the one-fifth normal standardized acid solution to neutralize a 200-c.c. sample of water the parts of calcium carbonate per 100,000 parts of water would be taken as

$$4.1 \times 5 = 20.5$$

Test for Acidity

If the water to be examined is acidulous the following method must be employed:

Carefully measure out as before 200 c.c. of the water to be tested and add two drops of the phenol-phthalein instead of the methyl orange. Load the burette with the one-fifth normal standardized solution of sodium carbonate and titrate as before, reading off as accurately as possible the number of cubic centimeters required to change the color of the water to a purple-red tint. The number of cubic centimeters thus required is then multiplied by the factor 5 to give the alkali equivalent of the acid present in the water. Thus, if 1.3 c.c. of the sodium carbonate was used in titrating the water contained acid equivalent to a sodium carbonate content of

$$1.3 \times 5 = 6.5 \textit{ parts}$$

per 100,000.

Permanent Hardness

The permanent hardness or hardness due to the sulphates is ascertained by the following test:

Filter a little more than 100 c.c. of the water to be tested and then measure exactly 100 c.c. into a clean vessel and add from the burette exactly 25 c.c. of the standardized sodium-carbonate solution. Evaporate this mixture to dryness in a porcelain dish on the water bath. Next, pour into the dish about 100 c.c. of distilled water, heat gently and stir to insure complete solution of the soluble solid matter in the dish. Next, filter the solution carefully and wash the filter well by pouring warm distilled water into it after the solution has passed through. Collect the filtered solution and the filter washings in the large porcelain basin, add two drops of methyl orange, titrate with the one-fifth normal standardized hydrochloric acid and read carefully the number of cubic centimeters required to cause the change from canary yellow to faint pink. The number of cubic centimeters of the acid solution required to bring about the color change is subtracted from 25 and the result multiplied by 5 to give the degrees of permanent hardness, expressed in their equivalent of parts of calcium carbonate per 100,000 parts of water.

Estimating Treatment

It is stated by reliable authorities that water which contains more than 20 parts per 100,000 of impurities, causing permanent and temporary hardness, should be treated before use. Whether the treatment should be made before the water is fed to the boiler is largely a matter of size of plant or amount of water used.

The quantity of lime required to treat water for temporary hardness (calcium and magnesium carbonates) may be estimated as follows: Pounds of fresh baked lime required per 1000 gal. of water equals number of parts of calcium carbonate in 100,000 (as shown by test for temporary hardness) multiplied by 0.0467.

The pounds of slaked lime required per 1000 gal. of water equals the number of parts of calcium carbonate multiplied by 0.0617.

And the pounds of caustic soda (sodium hydrate) required per 1000 gal. of water equals the number of parts of calcium carbonate multiplied by 0.0667.

Treatment for Sulphates

When lime is used for treating the carbonates the quantity of sodium carbonate or soda ash required to correct the permanent hardness may be estimated as follows: Pounds of soda ash required per 1000 gal. of water equals number of parts solid matter causing permanent hardness, multiplied by 0.0884.

When caustic soda is used for the carbonates not so much soda ash is required for the sulphates for the reason that the caustic soda and the carbonates react chemically to produce sodium carbonate (soda ash) which becomes available to react with the sulphates to produce sodium sulphate and calcium and magnesium carbonates (the latter being insoluble).

To estimate the quantity of soda ash required for the sulphates in such a case, proceed as usual to estimate the quantity required as though lime were to be used for the carbonates. Then, subtract from the quantity thus found, $^{106}/_{80}$ times the quantity of caustic soda used for the carbonates.

The foregoing materials for treating water are never 100 per cent. pure when bought in bulk and, consequently, it is necessary to allow for this when making up a treatment. The first step is to find out from the dealer what the percentage of purity is, then divide this percentage into the quantity actually required as estimated above and multiply the result by 100.

Testing Treated Water

It is well to test the treated water occasionally to make sure that the treatment is correctly proportioned. For this purpose the following additional material is needed: About a liter of standardized alcoholic soap solution of such strength that when employing a 200-c.c. sample of water, 1 c.c. of the solution will be equivalent to five parts of calcium carbonate per 100,000 parts of water, also about 2 oz. of a weak solution of silver nitrate.

The test is conducted as follows:

Partly fill an ordinary drinking glass with some of the treated water which it is desired to test. Into this put a few drops of the silver nitrate solution and note whether a snowy precipitate is formed or a brownish color is given to the water. The snowy precipitate is caused by the presence of carbonates and indicates that the quantity of lime should be increased. The brown color indicates an excess of lime.

Next draw a fresh sample of exactly 200 c.c. and pour it into a clean bottle of such size that the sample will not more than half fill it. Put some of the soap solution into the burette and read the quantity as accurately as possible. Next, run a small quantity of the solution into the bottle containing the test sample, shake the bottle vigorously for a minute or two and note whether a lather is formed. Continue to add soap solution and shake until a lather is formed which will cover the whole surface of the water when the bottle is lying on its side and remain for five minutes. When this point is reached, read on the burette scale the number of cubic centimeters of soap solution that was used. This number multiplied by 5 roughly indicates the total hardness in equivalent parts of calcium carbonate per 100,000 parts of water.

Finally, measure out another fresh sample, exactly 200 c.c. in quantity, and put this into the 22-oz. porcelain dish. Then, add to the sample two drops of methyl orange and two or three drops of the phenolphthalein. Titrate with the standardized hydrochloric-acid solution and note the number of cubic centimeters of the solution required to change the red color of the sample to a yellow shade. Then, run in more of the acid solution and read off the quantity required to turn the yellow to pink. The first reading multiplied by 10 gives the causticity, while the total cubic centimeters of the acid solution used, multiplied by 5, gives the alkalinity.

If the total hardness, as shown by the soap test, is greater than the alkalinity, it indicates insufficient proportion of soda ash in the treatment. If the total hardness is less than the alkalinity it indicates a too great proportion of soda ash. If the alkalinity is greater than the causticity it indicates an insufficient proportion of lime. If the causticity is greater than the alkalinity it indicates an excess of lime.

The method of estimating from the results obtained from the foregoing tests, what changes to make in the quantities of lime and soda ash, is exactly the same as that employed in making up the original quantities. To illustrate, if the alkalinity is greater than causticity by 1.5 c.c. of acid or

$$1.5 \times 5 = 7.5 \textit{ parts per } 100{,}000$$

the weight of the lime supplied per 1000 gal. of water should be increased by

$$7.5 \times 0.0467 = 0.35 \textit{ lb.}$$

If it should happen that the causticity was greater than the alkalinity by 1.5 c.c., or 7.5 parts per 100,000, then the weight of the lime supplied should be decreased by 0.35 lb. per 1000 gal. of water treated.

Other Scale Remedies

In addition to the staple chemicals dealt with in this series many other chemicals or preparations have been suggested and tried as scale preventives. Even such ordinary products as potatoes, tanbark, molasses, etc., have had their supporters. In addition, are the many proprietary preparations which have been placed on the market.

Kent's "Mechanical Engineers' Pocketbook" states:

"In cases where water containing large amounts of total solid residue is necessarily used, a heavy petroleum oil, free from tar or wax, which is not acted upon by acids or alkalies, not having sufficient wax in it to cause saponification, and which has a vaporizing point at nearly 600 deg. F., will give the best results in preventing boiler scale. Its action is to form a thin, greasy film over the boiler linings, protecting them largely from the action of acids in the water and greasing the sediment which is formed, thus preventing the formation of scale and keeping the solid residue from the evaporation of the water in such a plastic suspended condition that it can be easily

ejected from the boiler by the process of 'blowing off.' If the water is not blown off sufficiently often this sediment forms into a 'putty' that will necessitate cleaning the boilers. Any boiler using bad water should be blown off every 12 hr."

At one time kerosene oil was used somewhat extensively, its action being similar to that of the heavy petroleum oil mentioned in the foregoing paragraph. But the frequency of accidents due to carrying an open flame into boilers in which kerosene had been used caused its use to be largely abandoned.

Recently, graphite has been brought into prominence as a scale preventive and many engineers will testify that it has produced beneficial results. Its action is mechanical rather than chemical. Fed into the boiler with the water at regular intervals and in stated quantities, it tends to form a coating on the heating surface of the boiler which prevents the scale from adhering. The graphite also intermixes with the crystals of the scale-forming impurities and prevents them from cementing solidly together so that they exist only as a sludge or form of mud which can easily be blown out.

This series of articles on feed-water treatment has of necessity dealt with only the most common of the troublesome impurities encountered in water. Water from some sections contains many other impurities which have not been discussed here because of the difficulty of the analysis necessary to detect them. Some of these cause pitting and corrosion and are really dangerous when neglected. In some cases the nature of the water may be such that unless the treatment is very carefully planned and executed the effects produced may be as bad as, or worse than, the effects of the original water.

Taken as a whole the subject of water analysis and treatment is really so complex as to require the study of trained chemical experts. Trying to diagnose and cure feed-water troubles by home methods and remedies is much like trying to diagnose and cure human ills by home treatment. It works well enough when the trouble is simple and slight but in the long run it is often safest and cheapest to consult a good specialist who knows what to look for and how to prescribe and apply the remedy.

❖

Ashes as Fuel

Maschinenbau, under the above title, publishes an article which does not deal with a nostrum like the cobbler's mixture, which raised such a commotion some years ago, but points out that the amount of carbon in the ash taken from a boiler is rarely less than 10 to 20 per cent., and is frequently much more, especially in cases of forced firing. This means a loss of something like 4,000,000 tons of coal wasted per year in the German industries. A process for saving this is proposed, wherein the ashes are placed in a liquid having a specific gravity greater than that of the coal, but less than that of the ashes, so that the ashes sink to the bottom and the coal floats, both being continuously removed. In a trial of the apparatus 800 tons of coked coal were recovered from 2000 tons of ashpit waste. Of this some 500 tons were in pieces of from one-quarter of an inch to nearly 2 in. in size, while the rest was available for briquetting. The soot carried over to the tubes and back connection is some 60 per cent. carbon and the New York Edison Co. is investigating the practicability of briquetting it.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The enlightenment of China has been further advanced by the recent installation of 32 electric-lighting plants. To a population of over 400,000,000, thirty-two plants is only a gleam of hope, but it's also a beginning.

❖

Mr. Rockefeller distributed glittering Lincoln pennies to the children attending the church services.—Daily paper.

Gol' ding it, John, one of these fine days you'll go broke if you strew your wealth about so promiscus. Ye ain't goin' to riz th' price of ile on us, be ye?

❖

Too many wage checks are being cashed in saloons, complains an industrialist. Well, pay us in cash, and we'll undertake a more lavish distribution of our wealth.

❖

We should worry if here and now we did not acknowledge our gratitude to City Engineer Richard Smedberg, Stockholm, Sweden, for a copy of his bulletin, "Engelskspråkig väg- och Vattenbyggnadslitteratur." We say all when we say, "Tackor sa mycket, Bror Smedberg."

❖

How the daily papers do slop over when a new power plant "approaches its final completion," whatever that means. Here's a case in point: "After years of gigantic toil and the expenditure of $19,000,000, this huge project, marking a new era in hydro-electrical development, is consummated. The now harnessed forces will be converted into 100,000 hp., and the natural energy, once squandered, will now whirr the wheels of industry." Some whirr! We can hear our chief say : Give this slush two lines of fact, and cut out the bunk!"

❖

"I dunno much," said the farmer, "an' more'n half I know ain't so." This listens like some of the information we get when we ask a company official what caused the boiler explosion.

❖

Suffered a terrible fright recently when a Denver dispatch said: "Pikes Peak has sunk 39 ft. in the last three years." It was a mistaken calculation, reports the Geological Survey. Now we won't be robbed of a favorite expression, "Pikes Peak or bust!"

❖

Water costs so much in London that the new buildings over a certain value have adopted the artesian well, 52 already being operated. Anybody got a scheme whereby the sunshine can be bottled up and charged for?

❖

Seems kind of peculiar that the Panama Exposition's Machinery Hall is being built of wood? Its eight acres of floor space demand over 7,500,000 ft. of lumber. Wood is cheap on the Coast, but when this quantity has been carved out, it will make quite a hole in the scenery.

❖

In New York City, 72,000 smokers asked the Public Service Commission to allow "smokers" on the surface and elevated lines. And some young ladies riz up, bless 'em! and said: "Let the dear men smoke; it keeps them from grouching." A medico said moderate smoking was beneficial. Looked like it was unanimous until Doc. Pease and two other old ladies made their spiel. This put a crimp in the petition, and we're still waiting, central.

❖

We have been invited (along with a hall-full of other people) to meet His Serene Highness Albert, Prince of Monaco; to learn about "the queen of the white ants found at Lake Hopatcong," and to visit an entomological society's museum. Thanks! But— His Sereneness is not in our set; we have always been sluggish about going to the ant, white, or just plain ant, and— Well, we frankly nourish a prejudice against all "bugs," human or the garden variety.

❖

Not long since, consolidation of industrial interests was the thing to do if the stockholders were to get theirs. Now, some of them have overdone it, and they're trying to "decentralize" their overconsolidation. Bit off more than they could chew?

Accounting System for Electric Companies

By Leroy W. Allison

SYNOPSIS—A comprehensive accounting system capable of expansion or contraction to meet the needs of the large or small electric-light and power company. This schedule is based on the system prescribed by the Public Utility Commission of New Jersey.

The value of a uniform accounting system for electric-power stations and auxiliary operations can hardly be overestimated. Present-day conditions demand a comprehensive and accurate system for estimating costs and profit, and necessitate the abolition of antiquated methods that revert to guesswork and neglect vital elements, or involve needless complications leading to uncertain results. It is also important that the system be capable of expansion or contraction as conditions require without a revision in regular form or order. Accordingly in considering such a system it is imperative that it afford accuracy in general schedules, completeness in individual classifications, and simplicity for adaptation in whole or in part.

The following is based upon a recently prescribed uniform system of accounting by the State Board of Public Utility Commissioners of New Jersey, and applies to electric-light, heat and power industries in that state. The standardization of this system for its purpose has been effected by a long period of study and investigation of numerous accounting methods employed locally and in other sections of the country, and of both individual and general application. No factor has been neglected that might tend to compose an adequate and comprehensive system; one to reasonably and consistently apply to large and small interests, and provide real value for individual application and public-commission treatment.

ASSET ACCOUNTS

(1) Fixed Capital Installed.
(2) Fixed Capital, Tangible and Intangible.
(3) Construction Work in Progress.
(4) Floating Capital
  - (a) Materials and Supplies.
  - (b) Current Assets.
    - (c) Cash.
    - (d) Bills Receivable.
    - (e) Accounts Receivable.
    - (f) Interest and Dividends Receivable.
    - (g) Other Current Assets.

(5) Special Deposits
  - (a) Coupon Special Deposits.
  - (b) Other Special Deposits.

(6) Investments.
(7) Reacquired Securities.
(8) Sinking Funds.
(9) Other Special Funds.
(10) Prepayments.
(11) Suspense
  - (a) Unamortized Debt Discount and Expense.
  - (b) Property Abandoned.
  - (c) Other Suspense.

(12) Corporate Deficit.

EXPLANATION OF ASSET ACCOUNTS

(2) Fixed Capital, Tangible and Intangible: That devoted to other than electric operations.

(3) Construction Work in Progress: Expenditures upon plant and equipment in course of construction, but not yet ready for service; upon completion of such work, the cost should be credited to this account and charged to the appropriate "Fixed Capital" or other accounts.

(4) Floating Capital, (a) Materials and Supplies: Including cost, with transportation charge, of all such acquired; the salvage value of discarded equipment, and of equipment, materials and supplies returned to store, regardless of whether to be consumed in construction or in operation, or later to be sold; inventories of materials and supplies should be taken at least annually, and any shortages or overages credited or debited to this account. (b) Current Assets: Sub-division. (c) Cash: Including such coming into the possession of the company in which there is a beneficial interest; credit this account with all cash disbursements of company; (d) Bills Receivable: Including the cost of all negotiable paper, as demand notes, drafts, etc.; (e) Accounts Receivable: Including all other than negotiables; (g) Other Current Assets: Including all such not includible under any previous account.

(5) Special Deposits, (b) Other Special Deposits: Including all moneys and bank credits deposited for other special purposes not elsewhere provided for.

(6) Investments: Cost of all properties acquired not for use in present operations, but as a means of obtaining control of other companies, as foreign corporation stocks, etc.; investments should be classified as bound, those held subject to a lien of some character, and free, those held free of all liens.

(9) Other Special Funds: Including any such owned or held in trust for specific purposes not elsewhere provided for.

(10) Prepayments: Providing for taxes, insurance, rents, etc., paid in advance of the period to which they pertain.

(11) Suspense, (c) Other Suspense: Including all debits not provided for elsewhere, and of uncertain final disposition, as expenses of preliminary surveys, plans, investigations, etc., of projects under contemplation; where any such project be later carried to completion, amounts so expended should be credited to this account, and later charged to the proper Fixed Capital account.

(12) Corporate Deficit: To show the debit balance, if any, in the "Corporate Surplus or Deficit Account."

LIABILITY ACCOUNTS

(1) Funded Debt Account.
(2) Unfunded Debt Account
  - (a) Taxes Accrued.
  - (b) Receiver's Certificates.
  - (c) Judgments Unpaid.
  - (d) Interest Accrued.
  - (e) Other Accrued Liabilities.
  - (f) Dividends Declared.
  - (g) Bills Payable.
  - (h) Advances from Other Companies.
  - (i) Consumers' Deposits.
  - (j) Other Accounts Payable.
  - (k) Other Unfunded Debt.

(3) Permanent Reserves
  - (a) Premiums on Stocks.
  - (b) Other Permanent Reserves.

(4) Temporary Reserves
  - (a) Contractual Reserves.
  - (b) Non-Contractual Reserves
    - (c) Accrued Amortization of Capital.
    - (d) Unamortised Premium on Debt.
    - (e) Other Required Reserves.

(5) Optional Reserves
  - (a) Casualty and Insurance Reserve.
  - (b) Other Optional Reserves.

(6) Caital Stock Accounts.
(7) Corporate Surplus.

EXPLANATION OF LIABILITY ACCOUNTS

(1) Funded Debt Account: To be divided into classes, such classes being determined by the four characteristics: Mortgage or other lien or security therefor; rate of interest; interest dates, and date of maturity. Account to include "Debentures," as promissory notes unsecured by mortgage or other lien, and such securities commonly known as "plain bonds."

(2) Unfunded Debt Account, (e) Other Accrued Liabilities: Including liabilities not elsewhere provided for, particularly those accruing from day to day, but not becoming due until a certain date, as interest, rent, taxes, etc.; (h) Advances from other companies: Such advances as may be received to pay for construction or additions and betterments to the plant and equipment, or for any other purpose; (j) Other Accounts Payable: Open accounts to miscellaneous creditors as not elsewhere provided for; (k) Other Unfunded Debt: Including all unfunded debt of the company not otherwise provided for by this schedule.

Permanent reserves are those that must be maintained intact during the life of the company; temporary reserves are those not intended to remain intact during the life of the company. Contractual reserves are those necessitated by contracts of the company, such as to cover sinking funds provided for in mortgages, and the like. Non-contractual reserves are those of a temporary nature, raised without being required under any contract.

(3) Permanent Reserves, (b) Other Permanent Reserves: All reserves not otherwise provided for, created to remain intact during the life of the company.

(4b) Noncontractual Reserves, (c) Accrued Amortization of Capital: Providing for the crediting of such amounts as are

charged from time to time to "Operating Expenses," or other accounts, to cover depreciation of plant and equipment, and other amortization of fixed capital. (d) Unamortized Premium on Debt: To include the excess of cash value received over the sum of par value of securities, or other evidence of indebtedness and the accrued interest. (e) Other Required Reserves: Including all reserves not elsewhere provided for.

(6) Capital Stock Accounts: To include a separate account for each class of stock issued.

(7) Corporate Surplus: To show the credit balance, if any, in the "Corporate Surplus or Deficit Account."

FIXED-CAPITAL ACCOUNTS

(1) Land Devoted to Electric Operations.
(2) Organization.
(3) Franchises.
(4) Patent Rights.
(5) Other Intangible Electric Capital.
(6) General Structures.
(7) General Equipment { (a) General Office Equipment. (b) General Shop Equipment. (c) General Store Equipment. (d) General Stable Equipment.
(8) Dams, Canals and Pipe Lines.
(9) Power Plant Buildings.
(10) Furnaces, Boilers and Accessories.
(11) Steam Engines.
(12) Turbines and Water Wheels.
(13) Gas Producers and Accessories.
(14) Gas Engines.
(15) Electric Generators.
(16) Accessory Electric Power Equipment.
(17) Miscellaneous Power Equipment.
(18) Substation Buildings.
(19) Substation Equipment.
(20) Poles and Fixtures.
(21) Underground Conduits.
(22) Transmission System.
(23) Distribution System { (a) Overhead Distribution System. (b) Edison Tube System. (c) Other Underground Distribution System.
(24) Line Transformers and Devices.
(25) Electric Services.
(26) Electric Meters.
(27) Electric Meter Installation.
(28) Municipal Street-Lighting System.
(29) Commercial Arc Lamps.
(30) Glower Lamps.
(31) Electric Motors and Heaters.
(32) Electric Tools and Implements.
(33) Electric Laboratory Equipment.
(34) Other Tangible Electric Capital.
(35) Engineering and Superintendence.
(36) Law Expenditures during Construction.
(37) Injuries during Construction.
(38) Taxes during Construction.
(39) Miscellaneous Construction Expenditures.
(40) Interest during Construction.

EXPLANATION OF FIXED-CAPITAL ACCOUNTS

(1) Land Devoted to Electric Operations: Including land occupied by generating stations and their appurtenances; rights of way for transmission and distribution lines, and other electric operations; rights of way for canal and pipe lines, water rights of pondage, flowage and submersion.

(2) Organization: Cost of organizing company, and all other costs incident thereto.

(3) Franchises: Including the amount (exclusive of any tax or annual charge) actually paid as the consideration of such franchise or franchises.

(4) Patent Rights: Including cost of all rights acquired by the company in or under valid patents granted to inventors for inventions and discoveries which are necessary to the economical conduct of the company's electric operations.

(5) Other Intangible Electric Capital: Including the cost of all other property coming within the bounds thereof and devoted to electric operations.

(6) General Structures: Embracing the cost of all buildings of a permanent nature devoted to general corporate purposes, as general office buildings, general shops, general storehouses, etc.

(7) General Equipment, (b) General Shop Equipment: To include furnaces, boilers, gas producers, engines, electric generators, and other power apparatus used for the operation of machinery in shops; machine tools, cranes, hoists, shafting, belts and other shop equipment.

(8) Dams, Canals and Pipe Lines: Including the cost of all such devoted to the utilization of water power and delivery of the water to the headgate of turbine or water wheel; all wasteways from the outlet of draft-tube to the point of final discharge; gates, valves and other accessories.

(16) Accessory Electric Power Equipment: Including the cost of all electric equipment not included in other accounts, as busbars, regulators, station switchboards and equipment, circuit-breakers, switches, ammeters, voltmeters, wattmeters, and the like; also, headgate motors, pump motors, air-compressor motors, etc., and special high-tension transmission equipment at power stations.

(17) Miscellaneous Power Equipment: To include the cost of all miscellaneous equipment not included in other accounts, as belts, hangers, countershafts and other apparatus intermediary between the prime mover and the electric generator, cranes, hoists, machine tools, etc.

(19) Substation Equipment: Including the cost of all electric machinery and apparatus, and general equipment.

(22) Transmission System: To include the cost of all cables, wires, insulators and insulating material.

The transmission system is classed as that portion of the outside line or conductor system preceding the point of voltage reduction or other change, as when the electric energy generated (or received from another company) is conducted, either at the voltage of generation or at a higher voltage, to a point where it is lowered in voltage by means of step-down transformers, or changed as to kind and frequency by means of motor-generator sets, rotary converters, or frequency changers. Primary wiring, however, in lighting systems at not to exceed 4400 volts, four-wire, three-phase, is classed as a part of the distribution system; tie-lines between generating stations and substations follow a like rule. Line transformers are not included with the above-mentioned "step-down transformers."

(23) Distribution System, (a), (b) and (c): To include the cost of all distributing main conductors and feeders; all cables, wires, insulators and insulating material.

(25) Electric Services: To include the cost of all conductors and equipment used in connecting the distribution mains to render service to consumers. When consumers are required to pay all or part of cost of such service connections, only that portion of cost not chargeable to the consumer should be charged to this account; cost of renewing or modifying services is not included.

(28) Municipal Street-Lighting System: Including the cost of all property of the company specially provided for street lighting; not to include any part of general distribution system, but any particular apparatus in the utilization plant devoted to the municipal service.

(30) Glower Lamps: Including the cost of all such supplied to consumers, as well as municipal buildings, where there is an expectancy of life in service of more than one year.

(31) Electric Motors and Heaters: Including the cost of all such property, and appurtenances thereof as fans, etc., leased to consumers.

(34) Other Tangible Electric Capital: Providing for all such not otherwise included in accounts in this schedule.

(35) Engineering and Superintendence: To include all expenditures for such services on preliminary and construction work when such disbursements cannot be charged to specific construction.

(37) Injuries during Construction: Including all expenditures incident to injuries of all classes to persons when caused directly in connection with construction of electric plant and equipment.

(39) Miscellaneous Construction Expenditures to include the salaries and expenses of executive and general officers, clerks and the like, of the electric plant while under construction; also all construction and equipment items of a special and incidental nature not properly chargeable to other accounts in this schedule.

The foregoing accounts, comprising the three schedules, "Asset Accounts," "Liability Accounts" and "Fixed Capital Accounts," may be defined in general as the "balance sheet" or "indicant accounts." The balances of such at any particular time will show the current conditions of a company's affairs, so far as such conditions may be shown through accounts. These three schedules with their subsidiary classifications, represent additionally the main accounts of a company prior to its period of activity as a "going concern."

Commencing with active operation, a second schedule of accounts in which to classify the accounting history of the various changes of growth and conditions is necessitated. This schedule may be termed in general the "income account," comprising a group of accounts which being usually made up on a yearly basis and closed into one grand account of "Corporate Surplus or Deficit," ties

together both schedules, viz.: Indicant and Income Accounts.

The income account may likewise be divided into three general schedules, as: General revenue account, operating revenue account, and operating revenue deductions or operating expense account. These schedules with their general divisions and subdivisions will accordingly be considered in this regular order:

GENERAL REVENUE ACCOUNTS

- Non-Operating Revenues.
  - (1) Rents Accrued from Lease of Electric Plant.
  - (2) Miscellaneous Rent Revenues
    - (a) Leasehold Revenues.
    - (b) Other Rent Revenues.
  - (3) Interest Revenues
    - (a) Interest from Investments.
    - (b) Interest from Other Sources.
  - (4) Dividend Revenues.
  - (5) Miscellaneous Non-Operating Revenues.
  - (6) Non-Operating Revenue Deductions
    - (a) Rent Expense.
    - (b) Interest Expense.
    - (c) Dividend Expense.
    - (d) Miscellaneous Non-Operating Expense.
    - (e) Non-Operating Taxes.
    - (f) Uncollectible Non-Operating Revenues.
- Income Deductions
  - (7) Interest Accrued on Funded Debt.
  - (8) Other Interest Deductions.
  - (9) Rent for Lease of Other Electric Plant and Equipment.
  - (10) Miscellaneous Rent Deductions
    - (a) Joint Facility Rents.
    - (b) Miscellaneous Rent Deductions.
  - (11) Miscellaneous Deductions From Income
    - (a) Sinking Fund Accruals.
    - (b) Guarantee of Periodic Payments.
    - (c) Loss on Operations of Others.
    - (d) Other Contractual Deductions from Income.
  - (12) Amortization Deductions
    - (a) Amortization of Landed Capital.
    - (b) Amortization of Debt Discount and Expense.
    - (c) Amortization of Premium on Debt.
- Appropriation Accounts
  - (13) Bad Debts Collected.
  - (14) Other Additions to Surplus.
  - (15) Expenses Elsewhere Unprovided For.
  - (16) Dividends on Outstanding Stocks.
  - (17) Miscellaneous Appropriations
    - (a) Amortization Elsewhere Unprovided For.
    - (b) Appropriations to Reserve.
    - (c) Gifts to Controlled Corporations.
    - (d) Other Appropriations.
  - (18) Bad Debts Written Off.
  - (19) Other Deductions from Surplus.

EXPLANATIONS OF GENERAL REVENUE ACCOUNTS

(1) Rents Accrued from Lease of Electric Plant: To include all revenues from the company's interest in the electric plant or equipment held by others under some form or lease whereby it surrenders possession of such property.

(2) Miscellaneous Rent Revenues, (a) Leasehold Revenues: Including all revenues from any lease of term greater than one year. (b) Other Rent Revenues: Including all revenues from any lease or contract of entire term not exceeding one year, or which is held at will or upon sufferance.

(5) Miscellaneous Non-operating Revenues: To include all such accruing to the company not elsewhere provided for.

(6) Non-operating Revenue Deductions, (a) Rent Expense: To include all expense arising in connection with the procuring of revenues leased to others, as cost of negotiating contractors', collector's commissions, etc. (d) Miscellaneous Non-operating Expense: Including all such non-operating expenses not otherwise provided for. (e) Non-operating Taxes: Including all taxes accruing upon non-operating property.

(8) Other Interest Deductions: To include all interest accrued on receiver's certificates and on all interest bearing unfunded obligations of the company.

(10) Miscellaneous Rent Deductions, (a) Joint Facility Rents: To include profit or return upon any plant or equipment when such is maintained or operated by another company for the joint benefit of both companies, and under a joint arrangement for sharing the expense. (b) Miscellaneous Rent Deductions: To include all miscellaneous rents payable not otherwise provided for.

(11) Miscellaneous Deductions from Income, (c) Loss on Operations of Others: To include all liabilities accruing to the company through the terms of any contract whereby it is bound to contribute toward reimbursement of losses resulting from the operations of others. (d) Other Contractual Deductions from Income: To include all contractual liabilities not elsewhere provided for.

(12) Amortization Deductions, (a) Amortization of Landed Capital: Including such proportion of original money cost of landed capital as is necessary to cover the proportion of life thereof expired through the respective period of accounting. (b) Amortization of Debt Discount and Expense: Including that proportion of the unamortized discount and debt expense on outstanding debt applicable to the respective period.

(14) Other Additions to Surplus: Providing for the crediting of all additions to surplus because of erroneous accounting in prior fiscal periods, and all other additions not elsewhere assignable to specific accounts.

(15) Expenses Elsewhere Unprovided For: To include all expenses not chargeable to other accounts, such as fines levied on the company, donations to funds, etc.

(17) Miscellaneous Appropriations, (d) Other Appropriations: To include all optional appropriations made by the company not elsewhere provided for.

(19) Other Deductions from Surplus: Including all deductions from surplus because of erroneous accounting in prior fiscal periods, and all other deductions not otherwise provided for.

OPERATING-REVENUE ACCOUNTS

(1) Municipal Street-Lighting—Arc.
(2) Municipal Street-Lighting—Incardescent.
(3) Commercial Flat Rate Lighting.
(4) Commercial Flat Rate Power.
(5) Commercial Metered Lighting.
(6) Commercial Metered Power.
(7) Sale of Current to Railway Companies.
(8) Sale of Current to Other Electrical Companies.
(9) Rent of Electric Appliances.
(10) Electric Merchandise and Jobbing Revenue.
(11) Joint Electric Rent Revenue.
(12) Other Miscellaneous Electric Revenue.
(13) Sale of Steam.

EXPLANATION OF OPERATING-REVENUE ACCOUNTS

(8) Sale of Current to Other Electrical Companies: To include all revenues derived from the sale of electric energy to other electrical companies, to be distributed over their own lines to consumers, or portion thereof appropriated for their own benefit whether for light, heat or power.

(10) Electric Merchandise and Jobbing Revenue: Including all receipts from the sale of electric merchandise, and from electric jobbing.

(11) Joint Electric Rent Revenue: To include the profit or return upon property when a company engages in electric operations for the production of some of its product for the benefit of another or others, under an arrangement for apportioning the expense; such profit or return credited to be over and above any provision for wear and tear and depreciation of the particular plant.

(12) Other Miscellaneous Electric Revenue: To include all revenues derived from electric operations not included in any of foregoing accounts.

OPERATING-EXPENSE ACCOUNTS.

I. Production Expenses.

(1) Station Wages
- (a) Station Superintendence and Care.
- (b) Boiler Labor.
- (c) Producer Labor.
- (d) Engine Labor.
- (e) Electric Labor.

(2) Fuel
- (a) Fuel for Steam.
- (b) Fuel for Producer Gas.

(3) Other Station Supplies and Expenses
- (a) Water for Steam Power and Gas.
- (b) Water for Hydraulic Power.
- (c) Lubricants for Power.
- (d) Production Supplies.
- (e) Station Expense.

(4) Repairs to Station Buildings.

(5) Repairs to Steam Equipment
- (a) Boilers and Furnaces.
- (b) Boiler Apparatus.
- (c) Steam Accessories.
- (d) Reciprocating Engines.
- (e) Steam Turbines.
- (f) Mechanical Apparatus.

(6) Repairs to Hydraulic Equipment
- (a) Dams, Canals and Pipe Lines.
- (b) Turbines and Water Wheels.

(7) Repairs to Gas Power Equipment
- (a) Gas Producers and Accessories.
- (b) Gas Engines.

(8) Repairs to Electric Equipment
- (a) Electric Generators.
- (b) Accessory Electric Equipment.

(9) Miscellaneous Station Repairs
- (a) Tools and Implements.
- (b) Miscellaneous Station Equipment.

(10) Steam from Other Sources.
(11) Power Gas from Other Sources.
(12) Electric Energy from Other Sources.
(13) Joint Production Expenses—Credit.

II.—Transmission Expenses.

(14) Substation Wages.
(15) Substation Supplies and Expenses.
(16) Repairs to Substation Buildings.
(17) Repairs to Substation Equipment.

(18) Repairs to Transmission Lines
- (a) Repairs to Transmission Poles and Fixtures.
- (b) Repairs to Overhead Transmission Conductors.
- (c) Repairs to Underground Transmission Conduits.
- (d) Repairs to Underground Transmission Conductors.

(19) Joint Transmission Expenses—Credit.

III.—Electric Storage Expenses.

(20) Electric Storage Expenses
- (a) Storage Battery Labor.
- (b) Storage Battery Supplies.
- (c) Storage Battery Renewals.
- (d) Repairs to Storage Battery Accessories

IV.—Distribution Expenses.

(21) Distribution Wages
- (a) Superintendence.
- (b) Miscellaneous Distribution Labor.

(22) Distribution Office Expense.

(23) Repairs to Distribution Lines
- (a) Repairs to Distribution Poles and Fixtures.
- (b) Repairs to Overhead Distribution Conductors.
- (c) Repairs to Underground Distribution Conduits.
- (d) Repairs to Underground Distribution Conductors.

(24) Repairs to Electric Services.

(25) Transformer Maintenance
- (a) Setting and Removing Transformers.
- (b) Repairs to Transformers.

(26) Meter Maintenance
- (a) Setting and Removing Meters.
- (b) Meter Expense.
- (c) Repairs of Meters.

V.—Utilization Expenses.

(27) Commercial Arc Lamp Maintenance
- (a) Commercial Arc Lamp Expense.
- (b) Repairs to Commercial Arc Lamps.

(28) Commercial Incandescent Lamps.

(29) Consumers' Installation Expenses
- (a) Inspection of Consumers' Premises.
- (b) Repairs to Consumers' Installations.

(30) Municipal Street Arc Lamp Maintenance.
- (a) Municipal Street Arc Operation.
- (b) Municipal Street Arc Repairs.

(31) Municipal Street Incandescent Lamp Maintenance
- (a) Municipal Street Incandescent Operation.
- (b) Municipal Street Incandescent Repairs.

VI.—Commercial Expenses.

(32) Commercial Administration
- (a) Commercial Department Indexing.
- (b) Commercial Department Collecting.
- (c) Commercial Department Contracts.
- (d) Commercial Department Accounting.
- (e) Commercial Department Miscellaneous.

VII.—New Business Expenses.

(33) Promotion Office Expenses
- (a) Promotion Management.
- (b) Demonstrations.
- (c) Promotion Office Expense.

(34) Advertising
- (a) Advertising Salaries and Expenses.
- (b) Advertising Sundries.

(35) Canvassing and Soliciting.

(36) Promotion Wiring and Devices
- (a) Promotion Wiring.
- (b) Promotion Signs and Devices.

VIII.—General and Miscellaneous Expenses.

(37) Salaries and Expenses of General Officers.
(38) Salaries and Expenses of General Office Clerks.
(39) General Office Supplies and Expenses.
(40) General Law Expenses.
(41) Miscellaneous General Expenses.
(42) Insurance.
(43) Relief Department and Pensions.
(44) Electric Franchise Requirements.

(45) Injuries to Persons and Property
- (a) Accidents and Damages.
- (b) Law Expenses Connected with Damages.

(46) Stationery and Printing.

(47) Store and Stable (or Garage) Expenses
- (a) Store Expenses.
- (b) Stable Expenses.

(48) Miscellaneous Adjustments—Balance
- (a) Inventory Adjustments—Balance.
- (b) Discounts on Materials and Supplies.
- (c) Duplicate Electric Charges—Credit.

(49) Repairs of General Structures.
(50) General Amortization.
(51) Taxes.
(52) Uncollectible Electric Bills.

EXPLANATION OF OPERATING-EXPENSE ACCOUNTS

(3) Other Station Supplies and Expenses, (e) Station Expense: To include general and miscellaneous expenses in generating plant not specifically chargeable under other heads, such as lighting, heating and cleaning systems, fire-protection system, telephone, etc.

(5) Repairs to Steam Equipment, (f) Mechanical Apparatus: Including apparatus auxiliary to prime movers, such as condensers, packing tubes, renewing tubes, and pumps, oiling systems, etc.

(10) Miscellaneous Station Repairs, (b) Miscellaneous Station Equipment: To include particularly power transmission equipment and the like, as shafting, belting and clutches; motors, hoists, cranes, etc.

(11) Steam from Other Sources: Including the cost of all purchased or jointly produced steam consumed in the power plant of the electric department.

(13) Joint Production Expenses—Credit: Providing for the crediting of the portion of production expenses chargeable to other companies when any plant or equipment is maintained or operated by the accounting company for the joint benefit of itself and others, under an arrangement for apportioning the operating expenses. The portion so credited should not include any allowance for profit or return upon the value of the property.

(19) Joint Transmission Expenses—Credit: Providing for a similar crediting as under (13).

(22) Distribution Office Expense: To include the cost of all supplies and expenses of the office of the superintendent of the distribution department; maps, records, etc., of overhead and underground lines, cost of drawing materials, and the like.

(24) Repairs to Electric Services: To include the cost of repairing underground and overhead services leading from mains to consumers' premises.

(32) Commercial Administration, (e) Commercial Department Miscellaneous: To include all expenses incurred in selling electric power and products, and other items not included under classifications in commercial expenses or new business expenses.

(41) Miscellaneous General Expenses: Including the cost of telephone and telegraph service, and other miscellaneous expenses connected with the general management not provided for elsewhere.

(44) Electric Franchise Requirements: Including the cost of electric energy and other materials and supplies furnished to municipal corporations in compliance with franchise requirements, for which no payment is received.

(48) Miscellaneous Adjustments—Balance, (c) Duplicate Electric Charges: Providing for the crediting of all charges made to any accounts in electric operating expenses for electric energy or other product of electric operations consumed in such operations.

(50) General Amortization: To include charges to cover such wear and tear and obsolescence and inadequacy as have accrued during the period in the tangible electric capital of the company, and such portion of the life of intangible fixed capital as has expired or been consumed during the period.

(52) Uncollectible Electric Bills: Providing for the charging of amounts for electric service, etc., found impracticable of collection; upon such entry, the sum should be credited to the account receivable in which it was heretofore carried.

Absorption of Machine Vibrations

By Dr. Robert Grimshaw

In these days of "rattle and row" it is refreshing to find a society for the prevention of both—not a philanthropic association, but a business organization which has treated the problem from the technical and commercial points of view, and deliberately worked out methods and appliances for the various cases which have been presented to it, or which in the very nature of things have presented themselves.

The "Company for the Prevention of Noise and Vibration," of Berlin, has taken up this work which the increasing size and speed of machines has rendered so acute; "suiting the punishment to the crime"; using, among other methods and mediums, cork reinforced with iron, slabs of compressed woven materials, and a special material which the company has named "Silenz," for damping aërial sound waves, for use in music rooms, telephone cells, etc.

As regards the reduction of machine vibrations through the foundation; it is not enough to separate the machine (as, for instance, an unbalanced steam engine) from the surrounding walls by an air space, as the earth on which the foundation rests is elastic. So called sound-proof floors are also insufficient; as often, on account of their double construction, they act as sounding boards and increase the noise. Elastic material under the foundation does not prevent the vibrations being carried by the foundation bolts; even where the machines are not bolted down, it is in few cases sufficient to set them on cork or on similar inelastic material, as this is apt to be non-homogeneous and its elastic limit is liable to be exceeded locally; so that the very portions which carry the most weight will act inelastically and transmit the vibrations.

The methods of the company consist principally in taking up the vibrations in a construction or appliance where they are neutralized by friction. For instance, the foot

K, Fig. 1, of a machine is connected by a stud bolt S with a vibration plate P which hangs on three rods A, B, and C, the tension of which latter is so regulated by nuts that they can carry the weight of the machine. The

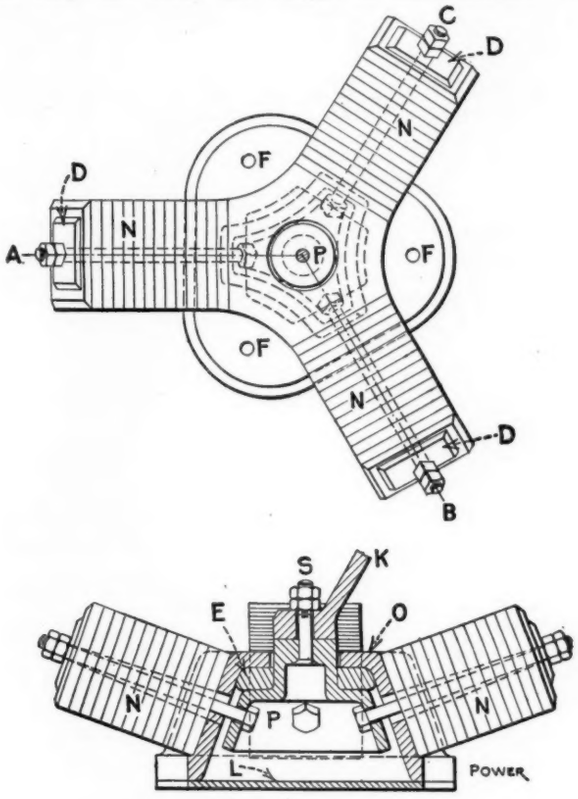


FIG. 1. PLAN AND SECTIONAL ELEVATION VIBRATION-ABSORBING DEVICE

stresses in the rods are taken up by the nuts and a pressure plate D, and transmitted to a series of elastic layers N, and further to a support O, which is fastened to the foundation or floor by bolts F. Between the vibration plate P and the support O there is an elastic layer E, which damps that portion of the vibrations that exist above the center of gravity. As this portion is much

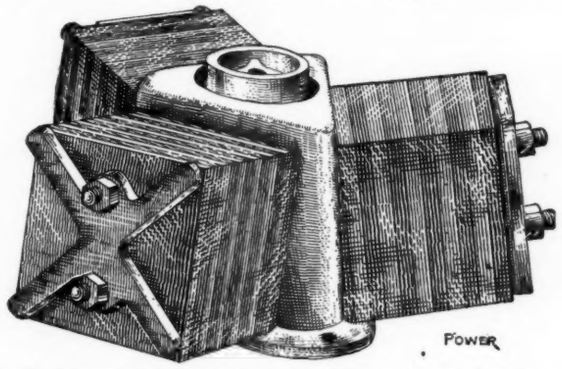


FIG. 2. PERSPECTIVE VIEW OF DEVICE FOR ABSORBING-MACHINE VIBRATION

less than the other, this second elastic layer may be thinner than N; L is soft-metal plate.

Fig. 2 shows the construction as adapted to taking up not only vertical but also horizontal vibrations, and, consequently, compound ones, such as elliptical vibrations.

In the case of electro motors (and especially of those for rotating phase currents) it is often difficult to distinguish if the vibrations are carried by the air or by the foundation. The Siemens-Schuckert works have already supplied over 100 of their motors with quieters of the system described. In the German navy, the motor-generator transformers are similarly insulated.

Iron beams and girders are insulated by completely covering them with plates of a special material which preserves its elasticity, without getting hard under the weight resting thereon.

Rushing Work on Panama Exposition

It has officially been announced that all of the main exhibit palaces of the Panama-Pacific International Exposition will be completed nine months before Feb. 20, 1915, the opening day; some of the buildings will be completed even earlier. This announcement, following the promise of the management made more than one year ago that the exposition would be completed nine months before the opening day and that the exhibit palaces would be built upon a definite schedule, confirms all that was said before. The preparations are further advanced today than were those of any other international exposition at a corresponding time before its formal opening; the work is proceeding upon schedule, and there will be no periods of delay or of congestion in the work. Building contracts provide bonuses for completion under the time limit.

A tremendous amount of preliminary work has been accomplished. Based upon the total amount of preparation required, the division of works estimates that today the exposition is more than two-thirds completed.

The exposition site, covering 635 acres of land near one of the most picturesque residential sections of San Francisco, was long since cleared of houses and other structures and fenced in. The underground work, completed almost throughout, included the reclamation of 71 acres of land from San Francisco Bay; the installation of a high-pressure water system for fire purposes, two-thirds completed; a low-pressure service water system, well advanced; an extensive drainage system (completed in the amusement concessions and foreign nations' district and nearing completion in the main exhibit district, where it is being carried along with the buildings themselves), and the laying of underground conduits for the electric wires for the transmission of light and power.

Ten of the huge exhibit palaces are under construction; framework of three is now rising, the flooring of practically all of the others is completed and the assembled parts are mostly ready to be raised to place. More than 70,000,000 ft. of lumber will be used in this main exhibit section, and over 25,000,000 ft. have already been delivered, with 40,000,000 ft. contracted for. Thirty-two steamers are carrying the lumber.

The streets, avenues, roads and paths are laid out, curbs are well along and a contract for the delivery of 70,000 cu.yd. of road rock, with an ample time limit, is being fulfilled.

A standard-gage railroad is being laid, the tracks being nearly all down and parts of the road in operation, conveying material. A completed freight ferry slip receives car floats regularly, and a commodious harbor on the water front, with a system of wharves, daily docks steamers with lumber and other building supplies.

The Service Building, housing the staff of the division of works, is completed, even to the gardens and lawns surrounding it, and has been in use all this summer.

Of the 12 great structures in the main group of exhibit palaces, the Machinery Building is erected, roofed and floored and is now receiving its covering of imitation Travertine stone, and its cornices and pillars. The Palace of Education is floored and the frame is about half up. Framing of the Palace of Food Products has been commenced and the floors of the Palaces of Agriculture, Liberal Arts and Manufacturers are nearly completed, while those of the Palaces of Varied Industries, Transportation and Mines and Metallurgy are being laid.

The contract for the construction of the Palaces of Fine Arts has been let and those for the Palace of Horticulture and the Festival Hall will be awarded soon, all to be completed well within the time limit.

Many other lesser structures are built or being built with rapidity. As an example, the building for the Republic of Honduras, ground for which was broken Aug. 20, is nearly all in frame and its floor is being laid.

The extensive park system is advancing as rapidly as the structural work. Along the Marina, the grass for the broad esplanade is growing luxuriantly and the sites of other parks and gardens are now graded and receiving their covering of fertile soil and enriching material. The shrubbery and plans for the landscape-engineering scheme are all on hand, ready for transplanting when desired, which will begin this autumn, with the erection of the exhibit palaces.

❋ ❋

Averaging Recording-Gage Records

By Lloyd W. Taylor

SYNOPSIS—Simple method of averaging recording-gage records, followed by explanation of method for those who wish to know the reasons why.

❋

Frequently it is desired to obtain the average of a recording-gage record to a fair degree of accuracy. To do this without either an averaging instrument or a planimeter is practicaly impossible. Since planimeters are more common than suitable averaging instruments, it is thought that the following method might be used to advantage.

In averaging a record by this method, four things must be known: The area A in square inches inclosed by the record; the straight-line distance D from pivot to point of the recording arm; the number of scale divisions C per inch of travel of the pen point, these scale divisions being in pounds per square inch, volts, amperes, or in whatever units the gage is intended to measure; the radius R of the center circle of the chart, that is, the distance in inches from the center of the chart to the zero center of the scale.

The first quantity A is found by means of the planimeter; the remaining three are simple measurements which vary with different gages. Once taken, these measurements may be kept for reference.

Assuming that these four quantities are known, the first step will be to solve the expression $\sqrt{A} \div 3.544\ D$, and unless some mistake is made this will be less than ½. In the accompanying table, the calculated value of $\sqrt{A} \div 3.544\ D$ is given and opposite the corresponding value of S, which appears in the following formula:

$$Av.\ reading = C\ (D\ S - R)$$

where D, C and R are the second, third and fourth known quantities respectively.

Sometimes it is desired to find the average reading for a part of a revolution of the chart. This is done by drawing a straight line from each extremity of the part of the record to be averaged to the center of the chart. Measure with a protractor, the angle which these lines make with each other. Divide 360 by the number of degrees in this angle and multiply the area inclosed by the two straight lines and the record by this quotient. Take the result equal to A and proceed as above.

For those who desire to know the reasons why the above is true, the following explanation is appended: The path of the recording pen, when the chart is stationary and pressure applied, is the arc of a circle whose radius is D. If the recording pen should remain stationary for a full revolution of the chart, a circle would be described. Call the area of this circle A. Then the length of a scale-divided arc from center to circumference of this circle is

$$2\ D\ sin^{-1}\frac{\sqrt{A}}{2\ D\sqrt{\pi}}$$

which equals

$$D\left(2\ sin^{-1}\frac{\sqrt{A}}{3.544\ D}\right)$$

in which the designated angle is expressed in radian measure. The expression in brackets is a generalization of the quantity S in the accompanying table.

Subtract from this arc, the radius R of the zero circle and multiply the remainder by the constant of calibration. The result is the reading at which the pen was held while the dial was revolved. For the purposes of these calculations, the area of the irregular record is taken as the area A of the averaging circle, and the average reading deduced from it.

VALUES OF S FOR USE IN FORMULA

$\frac{\sqrt{A}}{3.544\ D}$	S	$\frac{\sqrt{A}}{3.544\ D}$	S
0.01	0.0200	0.26	0.5261
0.02	0.0400	0.27	0.5468
0.03	0.0600	0.28	0.5676
0.04	0.0801	0.29	0.5884
0.05	0.1001	0.30	0.6093
0.06	0.1201	0.31	0.6303
0.07	0.1401	0.32	0.6514
0.08	0.1602	0.33	0.6726
0.09	0.1802	0.34	0.6939
0.10	0.2003	0.35	0.7152
0.11	0.2204	0.36	0.7366
0.12	0.2406	0.37	0.7581
0.13	0.2608	0.38	0.7796
0.14	0.2810	0.39	0.8012
0.15	0.3012	0.40	0.8230
0.16	0.3214	0.41	0.8449
0.17	0.3417	0.42	0.8669
0.18	0.3620	0.43	0.8890
0.19	0.3824	0.44	0.9112
0.20	0.4028	0.45	0.9336
0.21	0.4232	0.46	0.9561
0.22	0.4437	0.47	0.9787
0.23	0.4642	0.48	1.0014
0.24	0.4848	0.49	1.0242
0.25	0.5054	0.50	1.0472

[The above article may help to settle some of the points recently under discussion in these columns.—Editor.]

NEW PUBLICATIONS

HYDRAULIC TURBINES. By R. L. Daugherty. Published by McGraw-Hill Book Co., New York, 1913. Cloth, 6¼x9¼ in.; 156 pages, 96 illustrations, tables. Price, $2 net.

The purpose of the book is to give a general idea of water-power development and conditions affecting the turbine operation, a knowledge of the principal features of construction of modern turbines, an outline of the theory and the characteristics of the principal types, commercial constants, means of selection of type and size of turbine, and cost of turbines and water power.

In the limited space devoted to the subject the book covers the ground exceptionally well. For the most part it is simple and straightforward. The chapters on general theory and the theory of the various types of turbine naturally involve mathematics requiring a knowledge of trigonometry, and the same is true of the final chapter dealing with centrifugal pumps. The book may be recommended to students or to any one desiring a concise review of the entire subject of water power.

SHOP MATHEMATICS, Part II. Advanced Shop Mathematics prepared for the Extension Division of the University of Wisconsin. By Earl B. Norris and Ralph T. Craigo. Published by the McGraw-Hill Book Co., New York, 1913. Size, 6x9 in.; 214 pages, illustrated. Price, $1.50.

This book is an attempt to present the subject of applied mathematics, including elementary algebra, geometry and trigonometry, in a concrete rather than abstract form. For instance, algebra has been approached from the standpoint of engineering formulas, the authors pointing out that there is really nothing mysterious in such expressions, the symbols merely being more convenient to handle than the quantities they represent. Mensuration is handled in a very practical manner and free use is made of illustrations. The use of logarithms, trigonometric tables and curves is fully explained and, although in a few instances the authors have lapsed into the abstract the treatment of the subject in general and the selection of problems are thoroughly practical.

HEAT. A MANUAL FOR TECHNICAL AND INDUSTRIAL STUDENTS. By J. A. Randall. John Wiley & Sons, New York. Cloth, 5½x8 in., 331 pages; 77 illustrations; 15 tables. Price, $1.50.

Here is a book treating the subject of heat and thermodynamics that students and practical men alike have long felt the need of. The author has succeeded in his endeavor to furnish the general student or reader with such insight into the nature of heat and its effects as shall enable him to comprehend, reasonably, the operation of various power processes.

The author begins with an understandable treatment of the various forms of energy and leads into specific heat, calorimetry, expansion of gases and heat transmission by convection, conduction, radiation and treats on insulating materials.

The manner of treating the functions and heat exchanges and losses in steam, gas and refrigeration plants is, indeed, admirable. Simple shaded diagrams are used, and as the author does not resort to the usually inexcusable practice of using calculus and other higher mathematics in his treatment of the subjects, but instead requires only a knowledge of formulas from his readers, power-plant operating engineers will greatly appreciate the work, and find it of much value in giving them a good working knowledge of a branch of their work that they have left to the technical graduate for want of a proper book by which to acquire it themselves.

The technical man, too, will find it a valuable addition to his library.

HENDRICKS' COMMERCIAL REGISTER. Twenty-second annual edition. Published by Samuel E. Hendricks Co., New York City. Cloth; 1666 pages; 12x5½ in. Price, $10.

This well known register, established in 1891, has reached its 22d annual edition, which is forcible evidence of its wide use and usefulness. It furnishes complete classified lists of manufacturers for the benefit of those who want to buy as well as for those who have something to sell. It covers very completely the architectural, engineering, electrical, mechanical, railroad, mining, manufacturing and kindred trades and professions and establishes a direct link between the buyer and seller. The present is by far the most complete edition, requiring as it does 138 pages of index and representing the manufacturers of over 6000 articles, none of which has appeared in any previous edition. The total number of classifications is over 55,000, each representing the manufacturers or dealers of some machine, tool, specialty or material required in the architectural, engineering, mechanical, electrical, railroad, mine and kindred industries. There is a total of 437 pages of new matter, the whole representing upward of 390,000 names and addresses. An important feature is the simplicity of its classifications, which are so arranged that the book can be used for either purchasing or mailing purposes.

The value of the book for purchasing purposes is not confined to its complete classifications alone. It also gives much information following the names of thousands of firms that is of great assistance to the buyer and saves the expense of writing to a number of firms for the particular article required. There is also included the trade names of all articles classified as far as they can be secured. These trade names appear in parenthesis between the names and addresses under the classifications where they appear. The book is revised, improved and issued annually.

PRINCIPLES OF INDUSTRIAL ORGANIZATION—By Dexter S. Kimball. Two hundred and sixty-eight 6x9-in. pages; 19 illustrations; cloth bound; indexed. Price $2.50, McGraw-Hill Book Co., New York, N. Y.

This book is in a class by itself. No form or system of management is exploited in the book. No specific remedy for industrial evils is advocated. But the best of the modern systems and methods are presented through their principles with a careful weighing of advantages and disadvantages. Details, cards and forms are omitted. Thus this book stands head and shoulders above the ordinary run of management writings.

The book is the outgrowth of a series of lectures given by the author for the past few years to senior students at Sibley College, Cornell University. It is intended primarily for the needs of the young engineer, but its field of usefulness is much wider. Every practicing engineer or shop manager should have a definite knowledge of the principles of the various systems of management offered to him today.

Of the 14 chapters, the first four deal with the great inventions, their effects and corrective influences in industry. The first outlines the fundamental principles of the factory system, and the system that immediately preceded the present methods. Chapter 4 is concerned with corrective influences which are active at the present day.

Chapter 5 is devoted to "Modern Industrial Tendencies," taking up such matter as specialization, standardization, interchangeability, and the division of mental and manual labor. This is followed by a chapter on the forms of industrial ownership, and these six pave the way for the treatment of the principles of organization, in Chapter 7.

Chapters 8 to 12, inclusive, deal with specific features of factory organization. These are: Planning Departments; Principles of Cost Keeping; The Depreciation of Wasting Assets; The Compensation of Labor; Purchasing, Storing and Inspection of Materials.

Chapter 13 is devoted to the location, arrangement and construction of industrial plants, and the final chapter treats of theories of management. This is really a resumé and statement of the principles underlying industrial management, with a brief discussion of each. The discussion of these is most illuminating, and clears many points around which there has been controversy. It is gratifying to note that only seven principles are recognized, for previous writers have attempted to give anywhere from a dozen to seventeen or more.

An important feature of the work is frequent references to transactions of the American Society of Mechanical Engineers, other books and current technical literature. These recognize and point out the importance of the work of such men as Halsey, Taylor, Gantt, Church and Emerson. Thus the book has been written from a most careful study of the best of industrial management and practice of today, and with a full appreciation of its possibilities and importance.

New Government Publications—The Bureau of Mines of the Department of the Interior has the following new publications. Bulletin 50, a laboratory study of the inflammability of coal dust, by J. C. W. Frazer, E. J. Hoffman and L. A. Scholl, Jr., 60 pages, 95 illustrations. Bulletin 22, Analyses of coals in the United States, with descriptions of samples collected between July 1, 1904, and June 30, 1910, by N. W. Lord, with chapters by J. A. Holmes, F. M. Stanton, A. C. Fieldner and Samuel Sanford. Part I, Analyses, pages 1-321, 1 illustration; Part II, Descriptions of Samples, pages 322-1200. This bulletin gives information of value to fuel-purchasing agents, mechanical engineers and other persons who wish to know the composition and heating value of different coals. It is not published for general distribution. Not more than one copy of either bulletin will be given to the same person. Requests for the publications should be made by number and title and addressed to the Director of the Bureau of Mines, Washington, D. C.

BOOKS RECEIVED

POWER-PLANT TESTING. By James A. Moyer. McGraw-Hill Book Co., New York. Second edition; cloth; 486 pages, 6x9 in.; 393 illustrations; tables. Price, $4.

ADVANCED SHOP MATHEMATICS. Part II. By Earle B. Norris and Ralph T. Craigo. McGraw-Hill Book Co., New York. Cloth; 214 pages, 6x9 in.; 218 illustrations; tables. Price, $1.50.

TECHNICAL GAS AND FUEL ANALYSIS. By Alfred H. White. McGraw-Hill Book Co., New York. Cloth; 276 pages, 5½x8¼ in.; 47 illustrations; tables. Price, $2.

PROCEEDINGS OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION. Published by the Society at Ithaca, N. Y. Cloth; 508 pages, 5¾x8¾ in.; illustrated. Price, $1.25.

THE POLYTECHNIC ENGINEER. Published annually by the Polytechnic Institute, Brooklyn, N. Y. Cloth; 138 pages, 6x9 in.; illustrated.

STEAM, ITS GENERATION AND USE. The Babcock & Wilcox Co., New York. Cloth; 335 pages, 7¼x10¼ in.; tables; illustrated.

TABLE OF ESTIMATED RADIATION. By Harry B. Perrigo, New Haven, Conn. Celluloid folder, 4½x7¼ in. Price, $1.

Greater Winnipeg Water Project

The engineering organization for the $13,000,000 Canadian water project of the Greater Winnipeg water district is being rapidly assembled, states "Engineering Record." On Oct. 4 members of the administration board chose S. H. Reynolds, of Victoria, as the first of three commissioners to handle the construction and J. H. Fuertes, consulting engineer, of New York, as consulting engineer to the commission. W. G. Chace, of Toronto, was appointed chief engineer.

Surveying for the project has started, and as soon as the rights-of-way have been secured a telephone line will be installed between Winnipeg and Shoal Lake, the source of the proposed supply.

The officials expect that actual construction will be begun next spring, and recommend, in view of the fact that the region is difficult of observation in the winter and spring, that prospective bidders visit the district at an early date.

Campello (Mass.) Boiler Explosion

At 6:40 o'clock on the morning of Thursday, Oct. 9, while opening the throttle valve on a 20x42-in. Brown engine, at the factory of George E. Keith Co., shoe manufacturers, Campello, Mass., a cast-iron elbow under the valve ruptured. The flying fragments and escaping steam so severely injured and scalded the engineer, Alonzo E. Nelson, as to necessitate his removal to the Brockton Hospital.

Nelson was alone in the engine room when the accident occurred and was presumably warming up the engine for the day's run. As his condition is such as to preclude the securing of his statement, the cause can only be conjectured.

It is thought that the failure was induced by a slug of water carried along with the flow of steam and the consequent impact at the elbow being sufficient to cause the rupture. Steam and water continued to issue through the break until the arrival of the fire department, which was summoned by the operating of the automatic fire alarm, when the fires were drawn and the stop valve closed.

Nelson has been employed by the concern for 32 years and this is his second serious accident. About four years ago there was an explosion of gases in the boiler room that nearly cost him his life and he was confined in the hospital for several weeks.

Problems of Technical and Industrial Education

In Philadelphia last spring, representatives of the Central Educational Institute of the Y. M. C. A., Drexel Institute, the Franklin Institute, School of Industrial Arts, Spring Garden Institute, Temple University, and the Wagner Free Institute of Science joined with representatives of the Philadelphia Trades Schools and the Philadelphia and Camden Public Schools in arranging meetings for the purpose of becoming acquainted with one another's work and the educational problems employers have to face. Wishing to avail themselves of the wide resources of the Public Education Association of Philadelpnia, members of the faculties of the participating institutions are now organizing a section of that association to be known as the Industrial and Technical Education Conference of the Public Education Association. The membership is to consist of educators and employers, and the purpose is to seek the solution of the problems arising from the needs of the vast numbers of young people who have never had proper opportunities for securing that knowledge which will pave the way to better service and higher responsibilities.

Arthur J. Rowland is chairman and Henry V. Gummere, secretary of the conference. It is hoped that the movement thus started will spread to include not only local representatives, but all those employers whose employees find in the large city opportunities which cannot be offered nearer. This means extending the work to a great many miles from Philadelphia, for classes could easily be arranged outside the city, managed by experienced teachers who are specialists in any given line of instruction.

SOCIETY NOTES

The Ohio Society of Mechanical, Electrical and Steam Engineers will hold its eleventh annual meeting at Columbus, Ohio, on Nov. 20 to 22. The election of officers will take place and some interesting papers will be read and discussed.

The Chicago Section of the American Society of Mechanical Engineers proposes holding four meetings this season. It is planned to have a dinner at each meeting and maintain an informal discussion. The subjects for the meetings will be "The Iron and Steel Industry of the Chicago District," "Steam Power Plants," "Internal-Combustion Engines," and "Refrigeration." The first meeting will be held at the Sherman House on the evening of Nov. 19, at which the principal speaker will be William A. Field, general superintendent of the Illinois Steel Co.'s plant at South Chicago.

"A New Centrifugal Pump with Helical Impeller" is the title of a paper to be presented at the regular monthly meeting of the American Society of Mechanical Engineers on Tuesday evening, Nov. 11, by C. V. Kerr, of the A. S. Cameron Steam Pump Works, New York. The reason for seeking a new type of pump is based on the characteristic behavior of the small steam turbine which is commonly used in power plants as the driving power for circulating pumps for condensers. The mathematical theory of the new type of impeller will be presented, also an illustrated description of the 8-in. experimental pump used, with methods and results of tests. Discussion will follow in which all are invited to take part. An informal dinner will be served at 6:30 p.m.

PERSONALS

H. W. Thompson is the new superintendent of the Azusa (Calif.) municipal light and power plant.

Fred L. Hunt was recently appointed chief engineer of the Greenfield (Mass.) Electric Light & Power Co.

A. H. Maynard is the new chief engineer of the Merchants Lighting Co. power plant at Little Rock, Ark.

E. A. Geoghegan, for the past two years with the Union Iron Works, Erie, Penn., has accepted a position as superheating specialist, with the Erie City Iron Works, Erie, Penn.

Etienne de Fodor, general director of the General Electric Co. of Budapest, tendered a banquet to 150 distinguished Hungarians on Oct. 9, to mark the twentieth anniversary of the company.

L. G. Denis, hydro-electric engineer for the Canadian Conservation Commission, recently completed a 1000-mile canoe trip in the investigation of water-power possibilities in northern Manitoba.

Dan Cubberly, for many years with George B. Carpenter & Co., Chicago, has been made vice-president of the Julius Pearse Fire Department Supply Co., Denver, Colo., and will henceforth devote his entire time to the interests of that company.

J. B. Shatzer, representing the Schutte & Koerting Co., in Pittsburgh, Penn., will give a "Safety First" lecture, covering automatic engine stops and triple service valves at the National Association of Stationary Engineers' regular meeting to be held in Pittsburgh, on Nov. 17.